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Assessment of the 1999 Snow crab (Chionoecetes opilio) fishery off eastern Nova Scotia (Areas 20 to 24).

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ABSTRACT

The 1999 total landings in eastern Nova Scotia (ENS) were 60% higher than those of 1998. There was a 15% increase in the seasonal catch-per-unit-of-effort (CPUE) and a 40% increase in total fishing effort compared to 1998. The increase in landings was the result of increase in individual boat quota of regular licenses in all Crab Fishing Areas (CFA)(25% in CFA 20, 33% in CFA 21, 32% in CFA 22 northern, 26% in CFA 22 outer, 50% in CFA 23, and 44% in CFA 24), the introduction of new allocations (for a total of 39.9t) for temporary fishermen in CFA 20, and increase in allocations for temporary fishermen in CFAs 23 (from 250 t to 400 t) and 24 (from 250 t to 575 t). The overall picture for ENS in 1999 (compared to 1998) can be summarized as follows: all CFAs have reached their quotas with a similar or higher CPUE (18% increase in CFA 21, 53% in CFA 22, and 13% in CFA 23). CPUE decreased slightly in CFA 20 (-8%) and remained similar in CFA 24. The reported fishing effort were higher in CFA 20 (92%), CFA 21 (12%), CFA 23 (41%) and CFA 24 (91%), but 15% lower in CFA 22.

The third trawl survey was carried out in ENS in 1999. In 1997 and 1998, biomass information from this survey was not considered reliable because of numerous uncertainties, such as the size-weight relationship and the discriminant function for adolescent and adult males. In addition, the rough bottom configuration found in ENS is quite different from what is found in the southern Gulf of St. Lawrence where this method has been developed. In 1998, a new size-weight relationship and discriminant function were established specifically for ENS snow crab population. In 1999, the technique for biomass estimation by taking bottom configuration factor into account has been investigated, and possible problems and solutions are discussed in this document. Biomass estimates for 1997, 1998 and 1999 are also presented and discussed

RÉSUMÉ

En 1999, les débarquements totaux dans l'Est de la Nouvelle-Écosse (ENS «Eastern Nova Scotia») étaient 60 % plus élevés que ceux de 1998. On a noté une augmentation de 15 % dans les captures par unité d'efforts (CPUE) et une augmentation de 40 % dans l'effort total de pêche comparé à 1998. L'augmentation des débarquements résultait d'une augmentation des quotas individuels de permis ordinaires des crabiers pour toutes les zones de pêche de crabes (ZPC) (25 % dans ZPC 20, 33 % dans ZPC 21, 32 % dans le nord de ZPC 22 et 26 % à l'extérieur de ZPC 22, 50 % dans ZPC 23 et 44 % dans ZPC 24); l'augmentation est aussi attribuable à l'introduction de nouvelles allocations (pour un total de 39,9 t) pour les pêcheurs temporaires dans ZPC 20 et l'augmentation des allocations pour les pêcheurs temporaires dans ZPC 23 (de 250 t à 400 t) et 24 (de 250 t à 575 t). La vision d'ensemble pour ENS en 1999 (comparé à 1998) peut être résumée comme suit : toutes les ZPC ont atteint leur quotas avec des CPUE semblables ou plus élevées : (18% d'augmentation dans ZPC 21, 53 % dans ZPC 22 et 13 % dans ZPC 23). Les CPUE ont légèrement diminué dans ZPC 20 (-8 %) et sont demeurées semblables dans ZPC 24. Les efforts de pêche rapportés étaient plus élevés dans ZPC 20 (92 %), ZPC 21 (12 %), ZPC 23 (41 %) et ZPC 24 (91 %), mais de 15 % plus faibles dans ZPC 22.

Le troisième relevé au chalut a été effectué dans ENS en 1999. En 1997 et en 1998, l'information sur la biomasse obtenue à partir de ce relevé n'était pas considérée fiable à cause de nombreuses incertitudes, notamment la relation taille-poids et la fonction discriminante pour les mâles adolescents et adultes. De plus, la configuration inégale du fond dans l'ENS est très différente de ce qu'on trouve dans le Sud du golfe du Saint-Laurent où cette méthode a été mise au point. En 1998, une nouvelle relation taille-poids et une nouvelle fonction discriminante ont été établies spécifiquement pour la population du crabe des neiges de l'ENS. En 1999, la technique de l'estimation de la biomasse, qui tient compte du facteur de la configuration du fond, a été analysée et on décrit dans le présent rapport les problèmes et solutions potentiels. On y présente aussi les résultats et les discussions concernant les estimations de la biomasse pour 1997, 1998 et 1999.

INTRODUCTION

Harvesting of snow crab, *Chionoecetes opilio*, off the eastcoast of Nova Scotia began in the late 1970's. Landings rose rapidly with an increasing effort to a peak of 1,634 t in 1979 but landings and catch-per-unit-of-effort (CPUE) then collapsed within four fishing seasons (Tremblay et al. 1994). In 1985, this fishery was believed to be near commercial extinction (Elner and Robichaud 1985). However, a pulse of pre-recruits entered the commercial catches of snow crab in all CFAs in 1986 (Elner and Robichaud 1987). Total landings rose rapidly from 1989 to 1993 when peak levels were reached at 2016 t (Tremblay and Eagles 1996). In 1994, total landings declined by 23% to 1,551 t and remained stable at that level in 1995 and 1996. Catch rates in 1994, 1995 and 1996 were influenced by individual boat quota, whether or not soft-shell crab were retained, and reduced fishing season in some CFAs.

Analyses of CPUE, spatial distribution of effort, biomass and population structure from 1978-1993 indicate that the increased landings after 1986 resulted from an increase of abundance and biomass, an expanded fishing area and an increase of total effort (Tremblay and Eagles 1995). Although the market value of snow crabs was a factor in some years, fishing effort appears to have been driven mainly by catch rate (Tremblay and Eagles 1995). A high incidence of soft-shelled crabs (up to 50%) in the 1994 and 1995 catches was associated with a near record high effort (Tremblay and Eagles 1996).

From 1982 to 1993, the management of these fisheries has been based strictly on effort controls (seasons, licenses and trap limits). The number of licenses remained stable except for Crab Fishery Area 24 (CFA-24) where 7 new licenses were added between 1989 and 1991. Substantial changes to the management of these fisheries were introduced in each CFA from 1994 to 1997. Individual boat quota (IBQ) were imposed in all CFAs except for CFA 22 which operated with a fleet cap. Other changes introduced during that period were a mandatory logbook used by all fishermen for both dockside monitoring and the scientific data base, 100% dockside monitoring, landings not more than 0-10% soft-shell crabs, at-sea monitoring by certified observers and a biodegradable "panel" on traps to prevent ghost fishing. Some voluntary measures were requested by fishermen, such as a shortened season (CFA 21), no fishing on Sundays (CFA 22), a reduction of the trap limit from 30 to 25 (CFA 21) and tagging of soft-shell crab by the license holders (CFAs 20 to 24). The number of licenses in CFAs 20, 21 and 22 remained unchanged from 1994 to 1997. However, in 1995 nine temporary (1 year) licenses were allowed in CFA 23 and ten in CFA 24, with each temporary license permitted to land 4,536 kg with 10 traps per license. In 1996, the number of temporary permits was reduced to 3 in CFA 23 and 4 in CFA 24. However, in both CFAs, 13,608 kg was allocated to Natives on a temporary and communal basis. In 1997, the IBQ of fishermen in CFAs 23 and 24 was lowered from 24,948 to 23,587 kg in order to bring the four First Nations allocations (introduced in 1996) to full quota status while allocating quota to more temporary permits (six in each of these two CFAs) without increasing effort over the level of the past two years. It is intended that these four Native licenses will remain in the fishery in future years, thereby changing the total number of full-quota licenses to 24 (from 22) in CFA 23 and to 23 (from 21) in CFA 24.

In 1998, the IBQ of fishermen in CFA 21 was increased from 4,536 kg to 6,804 kg and the fishery reverted back to the regular fishing season. IBQs have been introduced for the first time in CFA 22 in 1998. An industry-designed separation of the fleet into northern and southern components was incorporated into the 1998 management plan, and fishermen were able to fish in only one area. The IBQ of the northern portion was 9,979 kg, while the southern component had 12,247 kg. In CFAs 23 and 24, the 1998 management plan allowed for an increase in IBQ from 23,587 to 24,948 kg and the allocation of 10 temporary permits, in each CFA, of 25 t that had to be fished outside "traditional" fishing grounds (Anonymous 1998; Biron et al. 1998b).

In 1999, IBQs of regular licenses were increased in all CFAs: CFA 20 from 9,072 to 11,340 kg; CFA 21 from 6,804 to 9,072 kg; CFA 22 'northern' from 9,980 to 13,154 kg; CFA 22 'outer' from 12,247 to 15,422 kg; CFA 23 from 24,948 to 37,500 kg; and CFA 24 from 24,948 to 35,870 kg (Table 1). New allocations (for a total of 33.9 t) were given to temporary fishermen in CFA 20, while existing temporary fishermen allocation increased from 250 to 400 t in CFA 23, and from 250 to 575 t in CFA 24. In CFAs 23, as in CFA 24, 100 t of the temporary allowed catch was allocated to previously unexploited grounds in the non-traditional areas (sub-areas 23D and 24E)(Fig. 1). Another noticeable change to the 1999 management plan is the separation of CFA 24 and the exploratory fishery 4X at the 4X/4W NAFO boundary line. The number of trap allowed was increased from 30 to 40 in CFA 24. Other management items remained as they were in 1998 for all the CFAs .

The first large-scale annual trawl survey was conducted in 1997 prior to the fishery and comprised 150 stations with a single station within each 10° latitude by 10° longitude grid (Biron et al. 1998a). Overall, there were 26 stations in CFA 22 and 62 sets in each of CFAs 23 and 24. The data from this first annual survey were analyzed and the first biomass estimations and/or abundance in numbers were produced for the area surveyed. However, at the Scientific Committee of the Regional Assessment Process (RAP) in January 1998, it was felt that it was premature to present these results due to uncertainties concerning the direct application of the kriging method developed for the southern Gulf of St Lawrence (SGSL) to ENS (Biron et al. 1998a). It was suggested that these points be addressed before attempting to analyze data and produce any biomass estimate.

In 1998, a new size-weight relationship and discriminant function were established specifically for ENS snow crab population. In 1999, the technique for biomass estimation by taking bottom configuration factor into account has been investigated and possible problems and solutions are discussed in this document. Biomass estimates for 1997, 1998 and 1999 are also presented and discussed in this document.

MATERIALS AND METHODS

Landings, catch rate and effort

In 1999, data on landings and fishing effort were obtained from the mandatory logbook completed by all fishermen for both dockside monitoring and the scientific database. Copies of the original completed logs and the compiled electronic database were obtained

from the Statistic Division of the Maritimes Region of the Department of Fisheries and Oceans (DFO). Thereafter, total seasonal landings for each CFA were obtained from a revised preliminary report produced by the Statistic Division in late December 1999, and may slightly differ from results presented in the Stock Status Report in January 2000. All fishermen submitted their logs, but not all logs were usable; some have one or more missing or erroneous values such as missing number of trap used or incomprehensive fishing position.

Traditional and non-traditional fishing grounds in CFA20 - Anecdotal information suggested that there may be some room to put additional effort in the marginal fishing grounds near St. Paul Island and outside of traditional grounds (based on recent logbook information on fishing locations), where the effort of traditional fishermen have been almost absent. DFO management, in consultation with regular license holders and other groups wanting to participate in this fishery, has drawn a line separating traditional and non-traditional fishing grounds (Fig. 1) for the 1999 fishing season. Permanent fishermen were allowed to fish anywhere in CFA 20, while temporary permit holders were confined to the non-traditional fishing grounds only. Traditional and non-traditional grounds are separated by the line formed by the points: on the CFA 19/20 line at 47°10'00" and 46°51'00" / 59°50'00" (Anonymous 1999).

Northern and outer areas in CFA 22 - In 1998, an industry-designed separation of the fleet into northern and outer (i.e.: Glace Bay Hole area) areas (also referred in this text as; portion, component, grounds or fishing grounds) was incorporated into the management plan, and fishermen were supposed to fish in only one area. This industry-designed separation has been made based on fishermen preference for a given area, and not for biological reasons. The Northern and outer grounds are separated by the line formed by the points: 46° 37' 00" / 59°44'00" and 46°00'00" / 59°51'00" (Anonymous 1999) (Fig. 1). The same measures were in effect in 1999, and landings, effort and calculated CPUE were determined for northern and outer grounds.

Traditional and non-traditional fishing grounds in CFAs 23 and 24- Traditional and non-traditional fishing grounds (Fig. 2) were determined as a result of the *ad hoc* RAP meeting in Sydney on April 23, 1998 (Anonymous 1998; Biron et al. 1998b). Permanent fishermen were allowed to fish anywhere in their respective CFA (traditional and non-traditional grounds), while temporary permit holders were confined to the non-traditional fishing grounds only. In CFA 23, traditional and non-traditional grounds are separated by the line formed by the points: on the CFA 22/23 line at 46°00'00" / 58°20'00", south to 44°50'00" / 58°20'00", west to 44°50'00" / 58°40'00", and southwest to 44°20'00" / 59°30'00" (Anonymous 1999). In CFA 24, traditional and non-traditional grounds are separated by the line formed by the points: from shore south to 44°10'00" / 61°10'00", east to the CFA 23/24 line (Anonymous 1999). These separations were still in effect in 1999.

Sub-areas of traditional and non-traditional fishing grounds in CFAs 23 and 24. - Following the stock assessment of 1998, DFO considered that a reasonable increase of 50% could be allowed in 1999 in CFA 23 and CFA 24. However, DFO Science group noted that within both traditional and non-traditional grounds, the heaviest effort was within the near shore area and an increased quota without effort distribution could increase exploitation above

acceptable levels. Therefore, DFO Management, in consultation with the Industry and DFO Science group, has drawn sub-areas within traditional and non-traditional fishing grounds (Fig. 1) to ensure the distribution of the fishing effort.

- CFA 23 sub-areas (Anonymous 1999):

  -A/B boundary; within traditional grounds, a line connecting the two points 46°00'00" / 58°24'56" and 44°42'52" / 59°54'58".

  -C/D boundary; within non-traditional grounds, at 45°00'00" latitude.

- CFA 24 sub-areas (Anonymous 1999):

  -A/B boundary; within traditional grounds, a line at 44°50'00" latitude.

  -C boundary; within non-traditional grounds, an area east of 62°10'00" longitude and north of 44°10'00" latitude.

  -D boundary; within non-traditional grounds, an area east of 62°10'00" longitude and south of 44°10'00" latitude.

  -E boundary; within NAFO Division 4W, an area west of 62°10'00" longitude.

In 1999, the total allowable catch (TAC) was divided into allocations for traditional and non-traditional grounds, and these allocations were further divided into smaller allocations for sub-areas within traditional and non-traditional grounds . None of the above mentioned sub-areas in CFAs 23 and 24, as well as the two components in CFAs 20 and 22 is biologically based.

Landings - Total landings by CFA are the sum of landings from the logs received for each CFA. The geographic distribution of landings was presented as a sum of total landings within each 10° latitude by 10° longitude grid (10 X 7 nautical miles grid). The fishing positions were taken from the logs.

CPUE and effort - The average CPUE corresponds to the ratio of total landings (y_i) to the number of trap hauled (tf_i) reported in the logs: $CPUE = \sum y_i / \sum tf_i$. The total effort (total number of trap hauls: F) was then estimated from total landings (Y) divided by average CPUE: $F = Y / CPUE$. The geographic distribution of fishing effort was presented as a sum of number of trap hauls within each 10° latitude by 10° longitude grid. The fishing positions were taken from the logs. The geographic distribution of average CPUE was calculated within each of these grids. Information from the exploratory fishery (CFA 4X) was analyzed separately from the "traditional" fisheries (CFAs 20 – 24).

Standardization of CPUE with the soak time of traps – The increase in TAC allowed in ENS in 1998 has been associated with changes in fishing and landing behavior which were imposed by some processor, e.g., landing every second day instead of each day in CFA

20(Biron et al. 1999). As a result, one of the recommendations put forward by the Scientific Committee during the 1999 RAP meeting was to evaluate the possible impact on the estimated fishing effort and resulting CPUEs. The change in fishing pattern may result in a false increase of CPUE value caused by a longer immersion time (underestimation of fishing effort). The similar phenomenon has been observed in CFA 12 fishery since 1994 (Hébert et al., 1999).

Based on fishermen's logbooks data, the mean annual trap soak time and the frequency distributions of fishing effort by trap soak time at an interval of 24 hours were produced for 1999. In addition, a relation between CPUE and the soak time (h) derived from the logbooks was established by fitting a power curve $CPUE = a(1 - e^{(-h/b)})$, where a and b are constant with an assumption that CPUE = 0 at soak time = 0. Based on this relationship, the relative fishing power (P_i) at each soak time interval (i) was estimated by: $P_i = CPUE_i / CPUE_{24}$; where P_i is the fishing power at a given interval of soak time i (e.g. i = 24hr, 48hr, 72hr, 96hr,...), $CPUE_i$ is estimated CPUE from the fitted curve at soak time i, $CPUE_{24}$ is the estimated CPUE at reference soak time (i = 24 hours). The reference soak time of 24 hours was chosen based on the fishermen' input as this duration seemed to be the most frequently used until 1998. By using the estimated fishing power P_i at a given soak time i, fishing effort (f_i) was standardized by: $F'_i = P_i * f_i$; where F'_i is the standardized total fishing effort at interval of soak time i, f_i is the non-standardized fishing effort at interval of soak time i. Thus, the total standardized fishing effort (F) in a given $year_j$ is $F = \sum(P_i * f_i) = \sum F_i$. The standardized mean CPUE in year j is estimated by: L_j / F_j, where L_j is total annual landings in year j.

Sea sampling

Sea sampling data were solely collected by certified observers. For each randomly-sampled trap, the total number of male crabs, the position and depth of the trap were recorded, and a sub-sample of 40 crabs were taken randomly for the following measurements: carapace width (CW), chela height (ChH), the carapace condition (on a scale of 1 to 5; Appendix I) and the hardness of the right claw (Foyle et al. 1989). Snow crab with claw hardness less than 68 in durometer readings were considered as soft-shell crab (Hébert et al., 1992).

Adult (terminal molt) and adolescent (non-terminal molt) individuals can be identified using chela morphometry by plotting logarithms of ChH against logarithms of CW (Conan and Comeau 1986). Data from adult and adolescent crabs fit into two distinct ellipses with parallel major axes (Conan and Comeau 1986). The following discriminant function;

$$Y = 19.775707 \ln(ChH) - 25.324040 \ln(CW) + 56.649941,$$

will assign individuals to the correct groups in 99% of cases (for adult males: $Y > 0$).
By plotting logarithms of ChH against logarithms of CW, the ENS data from adult and adolescent crab fitted into two distinct ellipses with parallel major axes (Biron et al. 1999).

In an attempt to compare some of the information obtained from the observer program with the result of the trawl survey (since it started in 1997), the observer's data from 1997 and

1998 have been re-analyzed using the new discriminant function developed for ENS (Biron et al. 1999).

Relationship between depth, surficial geology and crab density

Commercial fishing grounds and general knowledge- Information concerning the snow crab habitat and the fishing grounds was gathered by meeting with some of the fishermen from ENS. Excepted for CFA 20 where four of the five permanent fishermen were present at the same time, the meetings were usually done on one to one basis. The purpose of this exercise was to find out what they were looking for when searching for snow crab fishing grounds, i.e. depth, bottom type, or any other factor considered important. Questions were also asked concerning minimum and maximum depths ever fished (past and present), the type of crab found in various fishing locations or depth, and any other unusual information concerning the presence of crab on the grounds they fished.

Relationship between depth, surficial geology and reported fishing locations – In an attempt to verify if a relationship existed between depth, surficial geology and the reported fishing locations from the 1997, 1998 and 1999 logbooks, the data from these three parameters have been graphically linked by using a combination of MapInfo® and Vertical Mapper® programs. Detailed depth contour electronic charts covering most of ENS fishing grounds had been obtained from DFO Hydrographic Services in 1998. Hard copies of surficial geology maps (4013-G, 4015-G, 4039-G, 4041-G) covering all of eastern Nova Scotia grounds were also obtained from DFO Hydrographic Services. The fishing locations are from the corrected versions of the 1997, 1998 and 1999 mandatory logbooks.

Preliminary observations were made by plotting depth information, surficial geology and logbook information as different layers within MapInfo®, while Vertical Mapper® precisely link the information of each layer together. It was afterward possible to obtain precise depth contours and the bottom type for each location reported in the logbooks in 1997-99.

Relationship between depth, surficial geology and crab density from the trawl survey stations – In an attempt to verify if a relationship existed between depth, surficial geology and the density of crab found for each station during the 1997, 1998 and 1999 trawl surveys, the same preliminary observations as above have been done by using the trawl survey information instead.

Annual trawl survey

Trawl sampling – In 1999, the number of stations to be sampled for the large-scale annual trawl survey increased from 240 to 274 and the survey now covers most of the fishing grounds of ENS. A Bigouden *Nephrops* trawl originally developed for Norway lobster (*Nephrops norvegicus*) fishery in France is used (20 m opening with a 27.3 m foot rope on which is mounted a 3.2 m long, 8 mm galvanized chain; Conan et al. 1994). Each tow varies between 4 and 8 minutes at an average speed of 2 knots depending on the depth, current speed and sediment type. The horizontal opening of the trawl was measured every 7 seconds with a SCANMAR net sensor. The distance of each tow was estimated from the position

(Latitude / Longitude) recorded at the beginning and end of tow. The swept surface was then calculated based on the distance trawled and net width.

A systematic random design was used to determine the location of the 274 stations with a single station within each 10° latitude by 10° longitude grid. The duration of each tow as well as depth was recorded. The following measurements were taken for all snow crab captured in each tow: CW, ChH and the carapace condition for males; CW, the width of the fifth abdominal segment and the color of the eggs and gonads for females.

Kriging - A geostatistical method (kriging) was used to estimate annual and density contours of different biological categories of the snow crab biomass (Conan 1985; Conan et al. 1988). Kriging is described by Clark (1979) and its analytical basis was defined by Matheron (1970). It consists of two procedures (1) analyzing and modeling the covariance between sampling units as a function of distance between their locations, and (2) calculating optimal weights to be attributed to each sampling unit for calculating a predicted average characteristic of a given region to be assessed. Mapping of the entire surveyed area is the next step and, using point kriging and a fitted variogram; map of isodensity contours and isovariance contours is then generated for this area. We further use block kriging for estimating average density and variance over the whole area, and thereby estimating the total number of crab present in a given area. The model assumes that trawl efficiency is 100% for individuals larger than 50 mm CW. The abundance of snow crab estimated by kriging was converted into biomass according to the size-weight relationship and size-frequency histograms. To convert size to weight, size-weight relationships were calculated according to molt stage, the morphological maturity and sampling season. The size-weight relationship for adult hard-shell males in ENS is expressed by the function $W = 1.543 \times 10^{-4} CW^{3.206}$ (Biron et al. 1999).

Morphological maturity - We used the terminology "adolescent" (small claw) for non-terminal molt males and "adult" (large claw) to represent the terminal molt males (Sainte-Marie et al. 1995). The distinction between the two groups is based on the bivariate discriminant function obtained using CW and ChH measurements.

Carapace condition - Crabs were categorized into five groups based on the carapace condition and hardness (Anonymous 1994). Crabs identified as carapace condition 1 or "New soft" and carapace condition 2 or "Clean" with durometer reading less than 68 were considered as postmolt soft-shell crab.

Biological unit versus Management unit (see also Discussion section) – From a DFO-Science perspective, there are only two main biological concentrations of the resource in ENS, one in the north (CFAs 20-22) and the other in the south (CFAs 23-24). Furthermore, the management areas in ENS do not reflect biological distribution of the resource, and to use them as a reference point to present the trawl survey results compromise the reliability of the biomass estimates. Therefore, trawl survey results from 1997 to 1999 are shown based on biological units only (northern and southern ENS). However, in an attempt to help DFO-Management and the Industry to better manage the resource, estimates of exploitable biomass are presented for 2000, as well as the proportion (in percentage) of the biomass estimated by fishing grounds (CFAs and/or sub-areas) at the time of the survey in 1999.

Originally surveyed area versus Total surveyed area (see also Discussion section) – The number of trawl stations sampled has steadily increased from 150 in 1997 to 274 in 1999, and is expected to increase again in 2000. This has for consequence of increasing the total surveyed area, which in turn render objective comparison of trawl results very difficult between years. Therefore, trawl data will be analyzed for each year based on the originally surveyed area rather than the total surveyed area until the number of trawl stations sampled every year stabilizes. In southern ENS, the "originally surveyed area" refers to the surface used for Kriging in 1997 (17,623 km^2). In the case of northern ENS, it correspond to the surface used in 1998 (4,250 km^2).

Temperature – During the 1997, 1998 and 1999, it has been common practice to place a temperature probe (VEMCO Ltd) on the trawl for each tow. Although temperature data is sent to Hydrologic Services, DFO-Halifax, for proper analysis, some results are briefly discussed in this document.

Terminology – The trawl survey in ENS occurs 1-2 months before the fishery except in Area 24 in 1998. By contrast, in the southern Gulf of St-Lawrence, the survey occurs immediately after the fishery, which means the terminology for eastern Nova Scotia has a different meaning from that used in CFA's 12, 18 and 19. In this document; total biomass means all adult males greater than 95 mm at the time of the survey; exploitable biomass means adult males greater than 95 mm and of carapace condition 3, 4 and 5 at the time of the survey; recruitment to the fishery means adult males greater than 95 mm with a soft-shell and of carapace condition 1 and 2 at the time of the survey (these will not enter the fishery following the current survey, but the following year); and pre-recruits means adolescent males greater than 56 mm at the time of the survey.

RESULTS

Fishery

The 1999 total landings in ENS were 60% higher than those of 1998 (Table 2, Fig. 3). There was a 15% increase in the seasonal CPUE and a 40% increase in total fishing effort compared to 1998. The increase in landings was the result of increase in individual boat quota of regular licenses in all CFA (25% in CFA 20, 33% in CFA 21, 32% in CFA 22 northern, 26% in CFA 22 outer, 50% in CFA 23, and 44% in CFA 24), the introduction of new allocations (for a total of 33.9t) for temporary fishermen in CFA 20, and the increase in temporary fishermen allocation in CFAs 23 (from 250 to 400 t) and 24 (from 250 to 575 t). The overall picture for ENS in 1999 (compared to 1998) can be summarized as follows: all CFAs have reached their quotas with a similar or higher CPUE which increased 18% in CFA 21, 53% in CFA 22, and 13% in CFA 23. CPUE decreased slightly in CFA 20 (-8%) and remained similar in CFA 24. The reported fishing effort were higher in CFA 20 (92%), CFA 21 (12%), CFA 23 (41%) and CFA 24 (91%), but 15% lower in CFA 22. The seasonal geographic distribution is presented for landings (Fig. 4), CPUE (Fig. 5) and fishing effort (Fig. 6), as well as the location of the logbook positions recorded by fishermen (Fig. 7).

CFA 20

Fishing distribution – Fishing locations based on logbooks received show that the fishing effort of permanent license holders was concentrated along the snow crab boundaries of CFAs 19/20 and 20/21. Temporary fishermen also concentrated some effort in an area along CFA boundary 19/20, and further southeast along CFA 20 temporary line.

Landings - Total landings in 1999 are 90t (Table 3). This is more than double the TAC of 45 t that has been in effect since 1995, and also the highest recorded landing since 1978. Landings occurred within 5 weeks, from July 24 to August 27. The three vessels that fished and landed snow crab on July 24 (total of 2,556 kg, 90 trap hauls) have been included in the week starting July 25 for the logbook analysis (Table 4). In total, permanent and temporary fishermen landed 56 and 34t respectively.

CPUE and effort - The average CPUE was 32.3 kg/th in 1999, a slight decrease compared to 1998 (35.5 kg/th)(Table 4, Fig. 8). Meanwhile, total effort (2,793 trap hauls) increased by 120% compared to the 1,272 trap hauls in 1998 (Table 4, Fig. 9). The 1999 seasonal CPUE of permanent license holders of 31.6 kg/th is 11% lower than in 1998, while the total effort reported of 1,784 trap hauls in 1999 is 42% higher than those of 1998. For their first year, the temporary license holders have reported a seasonal CPUE of 33.7 kg/th and a total effort of 1,004 trap hauls for the non-traditional fishing grounds (Table 4).

At-sea sampling by observers - The 1999 catch composition derived from the at-sea samples showed that 90% of the measured crabs were adult males greater than 95 mm (Tables 5a and 6a), while this was 85% in 1997 and 88% in 1998 (Tables 7 and 8). Adolescent males accounted for 5% of the catches in 1999, compared to 11% in 1997 and 8% in 1998. The averaged seasonal soft-shell crab percentages were 6% in 1999, compared to 14% in 1997 and 1998. The mean CW was 113.3 mm in 1999, 118.2 mm in 1997, and 116.4 in 1998 (Figs. 10, 11 and 12).

CFA 21

Fishing distribution – The fishing occurred exclusively in the inshore area, the only fishing ground which seems to be productive within CFA 21.

Landings - Total landings in CFA 21 were 291t, 35% higher than those of 1998 (Table 9). However this was expected since the quota went up 33% (from IBQ of 6,804 to 9,067 kg). On average, all fishermen met their new IBQ. Landings occurred from July 22 to August 24, 1999.

CPUE and effort - The seasonal CPUE of 62.1 kg/trap haul is the highest value ever recorded since 1978, 17% higher than 1998 (53.0 kg/trap haul), which was the previous highest recorded value for that CFA (Table 10, Fig. 8). The effort (4,681 trap hauls) is 15% higher compared to 1998 (Table 10, Fig. 9).

At-sea sampling by observers - The soft-shell crab percentage of 11% is lower than the percentage reported for 1997 (28%) and 1998 (24%) (Tables 5b, 7 and 8). The sample size (N=1,413) of the measured crabs is 2 times higher in number than that of last year (679 crabs)(Table 6b). Adolescent males represented less than 10% of the catch composition (Table 5b) in 1999, compared to 5% in 1997 and 14% in 1998. The mean CW of at-sea samples in 1999 was 110.6 mm, while the one reported in 1997 was 112.2 mm, and 108.2 mm in 1998 (Figs. 10, 11 and 12).

CFA 22

Fishing distribution – In the northern area of CFA 22, the fishing effort was concentrated near shore towards CFAs 21/22 boundary, while the outer area fishermen concentrated in and around Glace Bay Hole.

Landings - CFA 22 total landings in 1999 were 31% higher than those of 1998 (Table 11). In the northern portion, 23 fishermen landed 303t within 4 weeks, while 14 fishermen landed 215t in a period of 3 weeks in the outer area (Table 12). This represent 25% and 42% increase in landings for the northern area and the outer area, respectively, compared to 1998 (Table 12). In 1999, one fisherman moved from the northern portion to the outer area compared to 1998. CFA 22 fished from July 22 to August 13 (northern fishing grounds) or August 7 (outer fishing grounds).

CPUE and effort - The average seasonal CPUE of 58.5 kg/th is 53% higher than that of 1998 (Table 11, Fig. 8). In the northern area, the average CPUE was 54.1 kg/th in 1999, representing an increase of 57% compared to 34.5 kg/th in 1998 (Table 12). The average seasonal CPUE of 65.7 kg/th in the outer area in 1999 is 44% higher than that reported for 1998 (45.6 kg/th) (Table 12). Total effort for CFA 22 in 1999 (8,841 trap hauls) is 15% lower than 1998 (10,387 trap hauls) (Table 12, Fig. 9). The breakdown shows that the seasonal effort for the northern area was 5,592 trap hauls in 1999, and 3,283 trap hauls for the outer area (Table 12).

At-sea sampling by observers – The soft-shell crab percentage of 16% is lower than the percentage reported for 1997 (38.5%) (Tables 5c, 7 and 8). The sample size (N=3,680) of the measured crabs is comparable in number to 1997 (N=3894)(Table 6c). Adolescent males represented less than 13% of the catch composition (Table 5c) in 1999, compared to 10% in 1997. The mean CW of at-sea samples in 1999 was 106.2 mm, while the one reported in 1997 was 99.9 mm (Figs. 10 and 12). Due to misunderstandings between governmental and non-governmental parties involved in the collection of sea-sampling data this year, no sea-sampling occurred in CFA 22 in 1998 (Biron et al. 1999).

Sample size was N=2,725 in northern area and N=955 in the outer area (Table 13). The soft-shell crab percentage was 18.5% in northern grounds, and 7.6% for the outer area. Adolescent males represented 11% of the catch composition in the northern area in 1999, compared to 16.5% in the outer area.

CFA 23

Fishing distribution – Fishing effort and distribution in 1999 has been influenced by the introduction of sub-areas to control the fishing effort associated with the increase in the TAC in CFA 23. Permanent fishermen have mainly fished in sub-area 23A and 23B, with little activity in 23C. Temporary fishermen have fished their respective sub-area (23C and 23D).

Landings – Total landings in 1999 were 1,300t (Table 14). A breakdown by status shows that permanent license holders captured 900t (713 t in 23A and 186t in 23B) and temporary permit holders landed 399t (299t in 23C and 100t in 23D)(Table 15 and 16). Landings occurred from July 25 to September 30.

CPUE and effort - The averaged seasonal CPUE of 87.3 kg/th is 13% higher than the average reported in 1998 (77.0 kg/th), and the highest recorded value for this CFA (Table 14, Fig. 13). The total effort of 14,888 trap hauls is 40% higher than 1998 (10,550 trap hauls)(Fig. 14). The 1999 seasonal CPUE of permanent license holders of 93.3 kg/th is 11% higher than 1998 (84.1 kg/th), while the total effort of 9,647 trap hauls is 35% higher than 1998 (7,122 trap hauls). The breakdown per sub-areas showed that 80% of the fishing effort by the permanent fishermen was put in sub-area 23A. The seasonal CPUE for 23A was 89.1 kg/th, and 114.2 kg/th in 23B. Meanwhile, temporary fishermen had a seasonal CPUE of 68.2 kg/th and a total effort of 4,392 trap hauls in sub-area 23C, and a seasonal CPUE of 118.2 kg/th and a total effort of 847 trap hauls in sub-area 23D (Tables 15 and 16). It should be noted that fishermen in 23C used older conical traps, compared to the newer high cone traps used in 23 D.

At-sea sampling by observers - The 1999 seasonal percentage of soft-shell crab is 6.4% of total catches (Table 5d). In 1999, 20% of the hard-shell adult males were under the legal carapace size limit of 95mm (Table 5d), which is similar to 1997. Adolescent male crabs accounted for 8.2% of the total catches in 1999, a decrease of 18% compared to 1998. The mean CW of at-sea samples in 1999 was 103.9 mm, compared to 99.2 mm in 1997 and 102.2 mm in 1998 (Figs. 10, 11 and 12).

The number of crabs sampled during the 1999 sea-sampling (N=8,875) is 75% higher than 1998 (Table 6d). The sampling per sub-areas was N=4,484 for the permanent fishermen (23A and 23B), N=3,311 for sub-area 23C, and N=1,080 for sub-area 23D (Table 17). The seasonal percentage of soft-shell crab in sub-areas 23A and 23B is 10% of total catches, compared to less than 1% in sub-area 23C and 12% in sub-area 23D (Table 17). In sub-areas 23A and 23B, 26% of the hard-shell adult males caught were under the legal carapace size limit of 95mm, compared to 16% in the sub-area 23C and 8.6% in 23D. Adolescent males accounted for about 8.5% of the total catches of permanent fishermen, while it was 6.8% for the temporary fishermen in sub-area 23C and 7.3% in 23D.

CFA 24

Fishing distribution – Fishing effort and distribution in 1999 has been influenced by the introduction of sub-areas to control the fishing effort associated with the increase in the TAC

in CFA 24. Permanent fishermen have mainly fished in sub-area 24A and 23B. Temporary fishermen have fished their respective sub-area (24C, 24D and 24E), with a little activity allowed in 24B.

Landings – Total landings in 1999 were 1,400t (Table 18). A breakdown by status shows that permanent fishermen caught 825t (535t in sub-area 24A and 288t in 24B) and temporary fishermen landed 75t in sub-area 24B, 295t in 24C, 99t in 24D, and 99t in 24E (Tables 16 and 19). Landings occurred from August 01 to September 29 in all sub-areas, excepted for 24E which was fished from August 11 to August 27.

CPUE and effort - The seasonal CPUE of 60.6 kg/th is similar to the average of 1998 (62.0 kg/th)(Table 18, Fig. 13). The total effort of 23,110 trap hauls is 90% higher than the total of 1998 (12,019 trap hauls)(Fig. 14). The 1999 seasonal CPUE of permanent fishermen of 64.4 kg/th is similar to 1998 (62.8 kg/th), while the total effort of 12,816 trap hauls in 1999 is 39% higher than those of 1998 (9,193 trap hauls). The breakdown per sub-areas show that 65% of the fishing effort by the permanent was put in sub-area 23A. The seasonal CPUE for 24A was 64.2 kg/th, and 64.8 kg/th in 24B. Meanwhile, temporary fishermen had a seasonal CPUE of 83.4 kg/th and a total effort of 900 trap hauls for sub-area 24B, 56.9 kg/th and a total effort of 5,187 trap hauls in sub-area 24C, 69.5 kg/th and a total effort of 1,420 trap hauls in sub-area 24D, and 38.0 kg/th and a total effort of 2,618 trap hauls in sub-area 24E, (Tables 16 and 19).

At-sea sampling by observers - The seasonal percentage of soft-shell crab (< 9%) derived from the sea-sampling data is 60% lower than 1998 (Table 5e). The 1999 data showed that 13% of the hard-shell adult males were under the legal carapace size limit of 95mm (Table 5e), representing a decrease of about 47% in undersize adult males compared to 1998. Adolescent males accounted for 13.6% of the total catches in 1999; a 30% increase compared to 1998. The mean CW of at-sea samples in 1999 was 104.8 mm, compared to 104.3 mm in 1997 and 99.4 mm in 1998 (Figs. 10, 11 and 12).

The number of crabs sampled during the 1999 sea-sampling (N=9,439) is 135% higher than in 1998 (N=3,998)(Table 6e). However, the distribution of the number of crabs sampled is not evenly separated between permanent (N=6,404) and temporary (N=3,035) license holders (Table 20). In 1999, the seasonal percentage of soft-shell crab in sub-areas 24A and 24B was 11% of total catches, compared to 6% in sub-area 24C and 24D, and 1% in sub-area 24E (Table 20). In sub-areas 24A and 24B, 16% of the hard-shell adult males caught were under the legal carapace size limit of 95mm, compared to 6% in sub-areas 24C and 24D, and 13% in 24E. Adolescent males accounted for 15% of the total catches of permanent fishermen, while this percentage is 8.4% for the temporary fishermen in sub-areas 24C and 24D, and 6.1% for 24E.

Standardization of CPUE with the soak time of traps

Excepted for CFA 23 where the effort is more or less equally separated in categories of 24 and 48 hours soak time, the effort in all the other CFAs in ENS was predominantly for 24-hour soak time in 1999 (Fig. 15). The power curves of CPUE in relation with soak time

reveal that CPUE reach a maximum (trap saturation) within the first 24 hours of soak time in all CFAs (Fig. 16). Overall, the mean annual adjusted CPUE and adjusted total fishing effort for all the CFAs of ENS were comparable to their respective uncorrected CPUE and uncorrected total effort.

Relationship between depth, surficial geology and crab density

Commercial fishing grounds and general knowledge

The following information was gathered between June 23 and August 26, 1999, following separate individual or group meetings with 28 commercial snow crab fishermen from all the CFAs of ENS. Another 5 snow crab fishermen were reached by phone. Three lobster fishermen from CFAs 23 and 24 were also interviewed during this survey.

Bottom type: Fishermen were unanimous about the best bottom type for fishing snow crab; they all prefer mud bottom. Some fish in mix gravel-mud bottom, but most avoid hard bottom because of the usual lack of crab.

Fishing depth: Fishermen from all CFAs were also unanimous about the minimum depth to fish snow crab; 125 m (70 fath). In CFAs 20, 21 and 22, fishing occurs at depth between 125 to 200 m. In this case, it seems that the lack of fishing effort at depth of 200 m or more may be due to the fishing device used (crab pot) in the fishery (strong currents) rather than the absolute absence of crab on these grounds. In CFAs 23 and 24, fishing occur at depth between 125 to 300 m, with the majority of fishermen fishing grounds situated between 150 to 225 m.

When asked about the presence of snow crab at depth of 90 to 125 m, all fishermen agreed that snow crab is commonly found at this depth range. It has been tried in the past, and still is sometime, but nobody fish these depth mainly because of the following two reasons;

1-There is a very high concentration of what some fishermen refer to as "junk crab", while the chance of finding a concentration of commercial crab is poor. The term "junk crab", in this case, regroups pigmy crab, skip molter, small crab barely making the limits, young crab (adolescent and white), and females (basically anything that is not commercial).

2-Hard bottom is usually the norm in depth shallower than 125 m in ENS.

When asked about grounds in depth shallower than 90 m, the consensus was again that some crabs are present there also, but to no amount, certainly not enough to make a living out of it. Two snow crab fishermen and one lobster fisherman have reported catching snow crab in their lobster gear this year at depth of 25 – 30 m. One reported catching 3 young undersized crab, another caught 1, and the last reported that 1 of his traps placed at 30 m was full of snow crab, with some making the limit (of 95 mm), and mostly older crabs.

Water temperature: None of the fishermen mentioned water temperature as a factor they consider in their selection of fishing grounds. The overall feeling was that temperature is not an immediate concern at the depth they are presently fishing. But all agreed that temperature can become a limiting factor in shallower water, or if there was a warming trend that could affect their fishing grounds.

Relationship between depth, surficial geology and crab density

Surficial geology – Surficial geology in ENS can be characterized by ten possible type of sediment; and of these 10 types, five appears on cross-sections only (Table 21). The five remaining types of surficial sediment found in ENS are: 1- Sable Island sand and gravel (which covers 54% of the surface covered by the trawl survey in 1999); 2- LaHave clay (10%); 3- Sambro sand (27%); 4- Emerald silt (5%); 5- Scotian Shelf drift (4%).

Relationship between depth and surficial geology – The types of bottom characterizing the surficial geology of ENS are not evenly distributed throughout the depths of the Scotian Shelf (e.g., the Sable island sand is only found between 0 and 100 m; LaHave clay is only found in the deeper water). Simple statistical analysis using both surficial geology and depth information combined to a third parameter to establish any kind of correlation was judged ill advised (pers. comm. Manon Mallet, DFO Science, Moncton, N.B.), therefore no further analysis was done.

Reported fishing locations – The majority (>95%) of the fishing locations reported in the corrected versions of the log books in 1997, 1998 and 1999 are situated in the deeper water (>100 m) of ENS (Figs. 7, 17 and 18). There was very little activity on the banks (i.e. depth < 100 m), and when present it was mainly near their edges. No clear relation could be established with surficial geology, fishing locations were found on all possible types of bottom, although the preferred fishing depth was mainly composed of silt or mix silt sediment types.

Crab density versus surficial geology – Trawls stations in 1997, 1998 and 1999 covered all five type of bottom present in the area surveyed. However, each bottom type present on the Scotian Shelf is not evenly or equally distributed, so the number of trawl station per bottom type is unequally distributed. No clear relation could be established between surficial geology and the density of crab found during the trawl surveys. Looking at each trawl stations since 1997, snow crab was present, or absent, in low to high density on all five bottom types covered during the surveys.

Crab density versus depth –Most of the time, trawl stations with high density of adult male snow crab of CW >95 mm are found in the deeper water (> 100 m), but adult males can also be found in the shallower water, usually in small number if present (1 or 2 adult crab per station). However, there is always 2-5 stations every year that are notable exception, and fairly high concentration of adult males were found on banks or along the shore, especially around the Missaine Bank area. The relation between depth and crab density is not so clear in the case of juvenile, adolescent female and undersized adult snow crab. These categories of crabs are present in high concentration in water less than 100 m deep.

Annual trawl survey

In 1997, 150 trawl stations were surveyed between May 15 and June 11 (26 stations in northern ENS and 62 in each of CFAs 23 and 24) and the total area covered for biomass estimation by Kriging was approximately 20,000 km^2 (Fig. 19). In 1998, a total of 214 stations (out of the 240) were sampled during the trawl survey. The remaining stations, all in CFA 23 non-traditional grounds, had to be abandoned because of the lateness of the survey and poor weather conditions during the fall. Out of the 214 trawl stations, 118 (CFAs 20, 21, 22 and 23 traditional) were surveyed before the fishing season, from May 20 to June 17; and 96 stations (CFA 24 and four stations in CFA 23) were surveyed after the fishing season, between Sept. 25 to Nov. 14 (Fig. 20). The total area covered for biomass estimation by Kriging in 1998 was over 24,500 km^2. In 1999, the number of stations increased to 274, and the survey was conducted prior to the fishery (May 3 to July 20). Trawl stations in 1999 were distributed as follow: 20 trawl stations in CFA 20, 15 in CFA 21, 26 in CFA 22, 122 in CFA 23 and 92 in CFA 24 (Fig. 21). In CFA 23, the trawl stations not realized in 1998 were done in 1999 instead, covering part of Banquereau Bank that would not have been normally sampled otherwise. The total area covered for biomass estimation by Kriging was approximately 27,500 km^2 in 1999. The different variograms used in the Kriging calculations indicate that there is a covariance effect between the values sampled ranging from 10 to 90 km. There were 7,810 males and 6,787 females collected and measured in 1997, 8,858 males and 7,102 females in 1998, and 7,162 males and 3,511 females in 1999.

Biological units

CFAs 20 – 22 - The estimated total area covered for biomass estimation by kriging in northern ENS was 4,400 km^2, of which 905 km^2 are found in CFA 20, 890 km^2 in CFA 21 and 2,615 km^2 in CFA 22 (417 and 2,198 km^2 in the northern and outer areas of CFA 22, respectively). The total surveyed area was 2,600 km^2 in 1997 and 4,250 km^2 in 1998. The exploitable biomass (B) found in the northern region of ENS was estimated at 1,510t (± 215%) in 1998 and 1,211t (± 133%) in 1999 (Table 22). The recruitment to the fishery (R-1) was estimated at 8,210 t (±26%) in 1998, compared to 1,201 (±106%) in 1999 (Table 22). In general since 1997, the recruitment (R-3, R-2, R-1) has been found in the continuous near shore area in CFAs 21 and 22. In 1998 a 'sudden' high concentration of R-1 estimated at 6,500t was found in the outer portion of CFA 22, but no major concentration of adult were observed in 1999. Overall, the density (in number) of juvenile and adolescent, as well as adults, has decreased in 1999 compared to 1998 (Fig. 22).

CFAs 23-24 - The estimated total area used for biomass estimation by kriging in southern ENS was 23,202 km^2, of which 13,878 km^2 are found in CFA 23 and 9,324 km^2 in CFA 24. The total biomass based on the total surface covered each year was estimated at 19,468t ± 44% in 1997, at 30,897t ± 43% in 1998, and at 31,856t ± 34% in 1999 (Table 23). The exploitable biomass (B) based on the originally surveyed area was estimated at 12,657t ± 52% in 1997, at 23,510t ± 48% in 1998, and at 17,056t ± 35% in 1999 (Table 23). The size

frequency histograms of adult males > 95 mm CW show three distinct pulses of future recruitment (R-3, R-2 and R-1) in 1997; one large and combined pulse of recruitment (R-3 and R-2) in 1998; and a substantial decline in recruitment and adults (mostly undersized crab) in 1999 compared to 1997-98 (Figs. 23 and 24). In general, during the period of 1997-99, most of the recruitment was found in the originally surveyed area, while by comparison very little recruitment to the fishery was found outside this area in 1999. The density of juvenile and adolescent, and adults has peaked in 1998, with a drastic decrease in the density of adolescent and total adults occurring in 1999, while the number of exploitable adults remained more or less constant (Figs. 23 and 24).

Management units

The 1999 survey indicated that there was 2,384 t of total biomass in the north, Area 20-22; and 31,810 t of total biomass in the south, Areas 23(A-D)-24(A-C). The fishery occurred after the survey and harvested 907 t in Areas 20-22 and 2,488 t in Area 23(A-D)-24(A-C). Thus assuming no other lossess, the exploitable biomass available for the 2000 fishery will be 1,477 t in Areas 20-22 and 29,322 t in Areas 23(A-D) –24 (A-C)(Table 24).

Biomass distribution

The 1997 contour of density map for adult males greater than 95mm show 3 major concentrations of adult male that are located in the "offshore" fishing grounds, with smaller patches inshore (Fig. 25). Of the 3 major concentrations, the one located in CFA 23 was mainly composed of crab of carapace condition 1 and 2, while the other two in CFA 24 were mostly crabs of carapace condition 3 and 4. The concentration of adult male found inshore of CFA 22 was mainly composed of crab of carapace condition 1 and 2.

In 1998, a major concentration of adult male was located between Canso, Misaine, Banquereau and Middle Banks, surrounded by smaller patches (Fig. 26). The high density patch found near Sable Island in 1997 is again present in 1998. The bulk of adult male crabs found in CFA 23 and 24 was composed of crab of carapace condition 3 and 4, while the continuous concentration in CFA 21 and 22 (northern) and a high density patch found in the outer portion of CFA 22 were mainly composed of crab of carapace condition 1 and 2.

The large concentration observed between Canso, Missaine, Banquereau and Middle Banks in 1998 has decreased in size in 1999, and has moved within the gully formed by Missaine and Banquereau Banks (Fig. 27). The high density patch found near Sable Island in 1997 and 1998 is present in 1999. No concentration of crab was found in the outer portion of CFA 22 in 1999.

Temperature distribution from the trawl surveys

In 1997, temperature data from the trawl survey shows that the coldest bottom temperatures were found in CFA 22 northern (-0.5 to 0.75°C), and most of the remaining grounds surveyed was between 1 to 4°C. Cold water temperatures (-0.5 – 1.74) were recorded for all stations in CFAs 20, 21 and 22 during the 1998 surveys, as well as most part

of CFA 23 traditional. In 1999, most of the grounds had bottom temperature between 0.76 – 2.75°C in CFA 23, between 0.0 and 1.75°C in CFA 24A and 1.76 to 4.75°C in 24B (going from colder water inshore to the warmest offshore). The warmest temperature were recorded in the southwestern portion of CFA 24 (Western Bank) in 1999, with temperature ranging from 5.4 to 6.8°C.

DISCUSSION

The 1999 total landings in ENS were 60% higher than those of 1998. There was a 15% increase in the seasonal CPUE and a 40% increase in total fishing effort compared to last year. The increase in landings was the result of increase in IBQ of regular licenses in all CFAs, the introduction of new allocations for temporary fishermen in CFA 20, and increase in temporary fishermen allocation in CFAs 23 and 24. The overall picture for ENS in 1999 (compared to 1998) can be summarized as follow: all CFAs have reached their quotas with a similar or higher CPUE which increased 18% in CFA 21, 53% in CFA 22, and 13% in CFA 23. CPUE decreased slightly in CFA 20 (-8%) and remained similar in CFA 24. The reported fishing effort were higher in CFAs 20 (92%), 21 (12%), 23 (41%) and 24 (91%), but 15% lower in CFA 22.

Standardization of CPUE with the soak time of traps

The increase in TAC allowed in 1998 has been associated with changes in fishing and landing behavior which were imposed by some processors, e.g., landing every second day instead of each day in CFA 20(Biron et al. 1999). Again in 1999, some snow crab processors in ENS dealt with the increase in snow crab allocations to be process by asking fishermen to restrict their landing, or again by offering a lower price per pound above a certain quantity of landings. For example, CFA 20 permanent fishermen were limited by the buyer to 2,000lbs / day quota for their landings. In CFA 21, fishermen were limited by the buyer to 4,000lbs / day quota during the first 2 days; then it dropped to 2,000lbs during the following days; and even to 700lbs / day at the end of the fishing season. As a result, one of the recommendations put forward by the Scientific Committee during the 1999 RAP meeting was to evaluate the possible impact this could have on the resulting CPUEs and estimated fishing effort. The change in fishing pattern may result in a false increase of CPUE value caused by a longer immersion time (underestimation of fishing effort). The similar phenomenon was observed in the CFA 12 fishery since 1994 (Hébert et al. 1999).

By applying the method developed for the SGSL to the 1999 logbook data, it was found that the distributions of fishing effort per 24 hours of soak time, the effort in all the other areas was predominantly for 24-hours soak time. An exception is found in CFA 23 where the effort is more or less equally separated in categories of 24- and 48-hour soak time. Furthermore, the power curves of CPUE in relation with soak time revealed that CPUE reach a maximum (trap saturation) within the first 24 hours of soak time in all CFAs. In other word, the fishing pattern currently occurring in all CFAs of ENS has little impact on the overall calculated CPUEs, and unstandardized CPUE were still used for this document.

Relationship between surficial geology, depth, bottom temperature and crab density

Squires (1990) describe the range of distribution of this species in the western Atlantic from Greenland to the Gulf of Maine, and at depth from 20 to 310 m but mostly from 70 – 280 m. Typical fishing depths off eastern and southwestern Nova Scotia are 90 m to 180 m. The records of distribution (Squires 1990) clearly indicate that Exploratory CFA 4X, the snow crab fishing area immediately west of CFA-24, is situated at the most southerly limit for the distribution for this species.

Relationship between surficial geology and crab density.

Although it seems as if a relation exist between bottom type and snow crab density, preliminary analysis has not confirmed such hypothesis. An important factor that might have rendered the statistical analysis futile was the surficial geology data source used for the analysis. The hard copies of surficial geology maps of ENS grounds, obtained from DFO Hydrographic Services and digitized by us, have been compiled and produced during the mid-70 and early 1980. Although the best and most updated data source available at this time, the generalization of the bottom type to surrounding grounds from a single core sample might not be precise enough for the type of analysis needed. A new technique called 'multi-beam scanning' is able to generate the type of precise data required, but this is not yet available for snow crab stock assessment (pers. comm. G.B. Fader, DFO Hydrographic Service, Halifax, N.S.). The matters are also complicated by the fact that bottom types are not evenly distributed throughout the Scotian Shelf, the depth ranges and/or temperature variations.

Relationship between depth and crab density

Although depth is the most readily available information used by fishermen (to determine their fishing locations) and the trawl survey (to determine the surface habitable by snow crab for the biomass estimations), it is not believed that depth on the Scotian Shelf is a limiting environmental factor. For example, the SGSL has depth and bottom type similar to those found on the major banks, but the combination to other environmental factors (bottom temperature, food source) still make it one of the preferred snow crab habitat in eastern Canada. In the case of ENS, depth is more of a 'coincidental' parameter that presently best describe the available snow crab habitat in ENS, but depth alone is not a limiting factor.

Temperature

Relationship between bottom temperature and crab density

According to Tremblay and Eagles (1996), snow crab on the Scotian Shelf are found mainly where summer bottom temperatures are less than 3°C, and these conditions are limited to the eastern Scotian Shelf and cold pockets off southwestern Nova Scotia. Adult snow crab have been reported in warmer bottom temperature (Biron et al. 2000), but it is

believed that molting crabs, being in fragile stage, might be more affected in warmer temperature.

In fact, it is believed that a cooling trend in the bottom temperature that started in early 1990 is partly responsible for the 'sudden' increase in the snow crab population observed during the same time in ENS. The cold water would have opened new habitat previously out of reach for the snow crab. This cooling trend seems to have stopped, and cold bottom temperature has remained more or less stable in its distribution since 1997-98 (Drinkwater et al. 1997; Drinkwater 1998). Bottom temperature is an environmental limiting factor, and if the cooling trend reverted to normal warmer temperature, lost of snow crab habitat is to be expected. In the south-southwestern area of CFA 24, temperatures are warm (5-7°C), and although the bottom type and depth are similar to prime snow crab grounds situated in the traditional area, extremely lower number of crab, if any, can be found there.

Population structure versus temperature

Data from the 1997 - 99 trawl surveys show that 1998 was the year with the highest density of crab recorded in all CFAs, which also coincided with the coldest temperature recorded since 1997. The coldest water, since 1997, has consistently been found in the northern portion of ENS, more specifically in the inshore portion of CFAs 21-22 (-0.5 to 0.5°C), which also has been one of the best productivity area in ENS since 1997.

The assumption that snow crab bearing barnacles on the carapace is "old" or "older" crab may not be true. The fact the barnacles are not the main epibiont species on the carapace in the SGSL may be closely related to the bottom temperature range (–0.5 to 2.5°C). In fact, the bottom temperature range in the inshore grounds CFA 20, 21 and 22 (inshore grounds) and in the inside areas of CFAs 23 and 24, where the barnacles are not frequently observed on the carapace, is similar to the range found in the SGSL. In the SGSL, barnacles have been observed in the Laurentian Channel where bottom temperatures are warmer. And in ENS, barnacle are found in the southern portion, being mostly noticeable around Sable Island and along the edge of the Laurentian Channel, where bottom temperatures are 3 to 5°C warmer than the near shore temperatures. Some of the crabs observed by us over the last year in ENS had all the characteristics of carapace condition 2 excepted for the pronounced presence of barnacles. Although it is a proved fact that areas that have not been previously exploited would have an accumulation of older crab over years, in the case of ENS, warmer temperatures in the southern part probably are in favor of the rapid growth of barnacles. An unknown portion of the crabs in ENS that we considered old because of the epibiont growth, should actually be classified with carapace condition 3. Presently, epibiont growth on carapace, if clearly visible, will automatically result with a carapace condition of 4. This needs an in-depth investigation to establish a proper key for the relative carapace age determination for ENS fishery.

Annual trawl survey and Biomass estimations

For the first time, the stock status in eastern Nova Scotia is based on a trawl survey, first introduced in 1997. Estimates of exploitable biomass for 2000 are 1,477 t for northern

ENS (CFAs 20-22) and 29,322 t in the southern part (CFAs 23(A-D) and 24(A-C)). Two problems with the survey were identified during the 2000 RAP meeting that would affect the biomass estimates. The first one being the steady increase in the number of trawl stations, passing from 150 in 1997 to 274 in 1999, and is expected to increase again in 2000. This has for consequence to increase the total surveyed area, which in turn render objective trawl results comparison between years next to impossible. In addition, the spatial model has assumed that the densities could be extrapolated over a large area than would be reasonable considering the abrupt changes in bottom topography. Until the number of trawl stations sampled every year stabilizes, trawl data will also be presented each year based on the originally surveyed area (i.e. calculation for each year based on a constant and same surface), but again these results should be viewed as an "index" for general comparison only. Although in this case the surface used for Kriging purpose is the same each year, the number of trawl stations in and around this surface has increased since 1997, reducing the "edge effects" near the original limits of this surface. These problems have probably resulted in overestimates of biomass in all years, although we consider that the 1999 biomass estimates are the most accurate available values.

There also appeared to be some inconsistency in the size frequency distributions that cannot be explained totally by survey methods, especially when comparing the histograms of 1998 with those of 1999. There are some indications that significant movement of the resource may be happening in slope areas and/or outside the survey area. Other possible reasons for the inconsistency of size frequency distributions would be a change in the time of the survey, a large die-off or changes in environmental condition. All these sources of uncertainty (further discussed below), as well as other factors having a potential impact on the biomass estimations should be carefully considered in the interpretation of this stock assessment results and in the management of these fisheries.

Determination of the projected habitat area

Unfortunately, statistical analysis performed to confirm the relation between the presence of crab, the bottom type and the depth have not been successful, and a 'scientifically proved' pattern in the distribution of the crab based on these parameters could not be established. However, following discussions with fishermen, permanent and temporary, as well as the analysis of the logbook and the trawl survey data of 1997 to 1999, it is obvious that at the time of the trawl survey (May – July) there is not "much" adult male snow crab ≥ 95 mm CW present on the major banks. And to include these grounds in the biomass estimation result in the overestimation of the snow crab population (Biron et al 1999). In the SGSL, the depth of 35 m is used as the limit above which snow crab concentration equal zero. Such limit applied to ENS would be useless since all the major banks are located between 50 to 100 m. Although we were trying to be conservative in our approach to delimit the snow crab habitat surface to be used for the biomass estimation; to have excluded all grounds above the 100 m would have resulted in an underestimation of the biomass. Often, when crab was found on the banks during the trawl survey, it was near the edge. Furthermore, forcing zeros at the 100 m (i.e., all grounds above 100 m = 0) would have lowered the density of crab / km^2 found at the base of the banks, which are supposed to be prime grounds. Therefore, and as a compromise until our knowledge of the snow crab

dynamics in ENS improve, the 70 m depth will used as the limit above which snow crab density will be equal to zero, but only the surface regrouping all the grounds between 90 m and 300 m will be used as the projected area to be used for the biomass estimation. The depth limit of 70 m was arbitrary chosen based on the fact that it is the minimum depth limit surrounding most of the grounds on the banks (i.e., 60 m comprise only small patches here and there on the banks), and Squires (1990) showing the range of distribution of this species at depth mostly from 70 – 280 m.

For females, and juvenile, adolescent and the undersized adult males, nothing is obvious concerning their distribution at the time of the trawl survey. We firmly feel that using the same projected area as for the adults ≥ 95 mm does not accurately estimate the total number of individual for each of these categories. However, our lack of knowledge and understanding of the dynamics and behavior each these categories stop us from presenting anything better. Therefore, and until further studies are carried out to improve our knowledge, it was decided to apply the same method as the adult males, but only to use the results as an index to compare changes from year to year.

Snow crab movement and removal rates

Movement seems more important and unpredictable in ENS than in the SGSL, and the magnitude may reach disturbing proportion. Take for example the sudden 'apparition' of R-1 in the outer portion of CFA 22 in 1998; passing from less than 100 t in 1997 to over 6,500 t in 1998, and again to less than 100 t in 1999. It almost seems as if a wave of recruits had just passed by during the 1998 survey, but we do not know where they went. The only other phenomenon that could explain this kind of variation, or the drastic drop in the 1999 recruitment in CFAs 22, 23 and 24 compared to 1997-98 would be mortality. Removals taking the form of cannibalism, predation, and natural or fishery induced mortality. The best example giving indication that removal may be very important is found in the traditional grounds of CFA 24 where the survey occurred after the fishery in 1998 and before the fishery in 1999, 6-7 months apart. During this short period, the estimated exploitable biomass passed from 13,410 t in 1998 to 9,319 t in 1999, and the total biomass passed from 17,265 t to 12,221; a significant 'removal rate' of 31% and 29% respectively. Although movement could explain some of this removal, it should be noted that no increase was found anywhere else in the surveyed area in ENS.

A significant loss (movement, mortality and/or some other factor not yet considered) must be considered in order to properly estimate the exploitable biomass for the next fishing season. The general decrease in the number of recruits and the exploitable biomass observed in CFAs 23 and 24 in 1999, as well as their respective sub-areas, can not be justified by the landings alone, nor by the cross-over into the next size category. If it is not mortality, then they are moving somewhere outside the surveyed area, or places outside the trawl stations.

Confidence interval and Management lines

In general, the smaller the area chosen for the biomass estimation becomes, the bigger our confidence interval becomes. In the same manner, the sum of all the sub-areas in a given

region is seldom equal to the estimation for the whole region. In other word, biomass estimations have been estimated for each sub-area within each CFA of ENS (excepted for 24D; and for 23C and D that were combined) for management purposes, but it might be a mistake to use the estimation for each given sub-areas rather than the whole region. For example within the region formed by CFAs 20, 21 and 22 (1999 compared to 1998), the density of snow crab (number of crab/km^2) for the recruits (R) has increased, while the density of exploitable adults has decreased in CFA 20; in CFA 21 both the recruits and the exploitable adults have increased in density, while both the recruits and adults density has decreased in CFA 22 during the same period. But there is no doubt that these areas are related, and what happen to one will affect the others; especially in CFAs 21 and 22 northern where the mutual boundary has been crossing right in the center of the high density patch since the trawl survey started in 1997. However, a decrease in the density of crab present in this high concentration patch may end up in an uneven distribution of the categories of crab in the future. It was observed in 1999 that the concentration of smaller recruits was more important in CFA 22 northern than CFA 21, while the concentration of exploitable crab was more important in CFA 21 than 22 northern.

In the same manner, one of the most productive areas for exploitable biomass since 1997 has consistently been the region surrounded by Canso, Misaine, Banquereau and Middle Banks, which is also where the boundary separating the traditional CFAs 23 and 24 passes, as well as where the boundaries of CFA 23A and 23B, and of 24A and 24B converge. The problem is that, with our current knowledge, it is impossible to determine in advance if a high concentration found in 23A a given year might not end up in 24B the following year.

Biological unit versus Management unit

Following the presentation of the trawl survey data during the snow crab RAP meeting in Moncton, January 18-20, 2000, the Scientific Committee recommended that biomass estimation be presented by biological concentrations rather than by CFA's as it is often the custom in stock assessment documents. Management areas in ENS do not reflect biological distribution of the resource, and to use them as a reference point to present the trawl survey results compromise the reliability of the biomass estimates. From a DFO-Science perspective, there are only two main biological concentrations of the resource in ENS, one in the north (CFAs 20-22) and the other in the south (CFAs 23-24). However, in an attempt to help DFO-Management and the Industry to better manage the resource, estimates of exploitable biomass are presented for 2000, as well as the proportion (in percentage) of the biomass estimated by fishing grounds (CFAs and/or sub-areas) at the time of the survey in 1999.

Conservation versus the actual exploitation rates

Although we feel confident that the 1999 biomass estimations are the best stock assessment available at present, values projected for 2000 may be over-estimated and must be interpreted with caution. In addition to the uncertainties mentioned above, they do not account for mortality of old carapace crabs. This is even more so in northern ENS where fishery related signs such as increasing CPUEs in recent years seems to contradict some

results from the trawl survey. For example, in northern ENS total landings in 1998 and 1999 were 657 t and 901 t, respectively, while the biomass of exploitable crab were estimated at 1,510 t in 1998 and 1,211 t in 1999. Therefore, and without taking into account confidence interval, mortality rates, movement or any other factor, this represent straight exploitation rates of 44 % in 1998 and almost 75 % in 1999 (but CPUEs were higher in 1999 than 1998). These two exploitation rates are surely lower if you consider that our approach to the biomass estimation is conservative, and the region seem to have been receiving a fair amount of adult crab migrating from CFA 19 in 1998-99. In 1999 alone, more than 17 tags from a tagging experiment (N=750) done in CFA 19 in 1998 have been returned by fishermen in CFAs 20, 21 and 22 (21 tags since Aug. 1998). By opposition, only 1 tags from CFAs 20, 21 and 22 (N=250) have ever been recaptured in CFA 19 (or the southern Gulf) since the crabs were released in 1997. Nevertheless, based on the trawl survey information, this northern area of ENS seems to have been managed under a high exploitation rate in 1999, while total biomass has decreased compared to 1998.

Fishery related data and the trawl survey data does not contradict one another, and are both good indicators of a stock status. In the specific case of northern ENS, it might simply indicate our lack of knowledge and the need for a model specific to that area. Until now, it has been treated has equivalent to southern ENS but this might be a mistake since its topography as a biological unit is closer to parts of SGSL. Crab movement, constant cold water and timing of the survey are believed to be very important factor in this area.

Recommendations

- For the first time, the ENS snow crab stock status is based on a trawl survey first introduced in 1997.
- Estimated results are given only for two areas, one in the north (CFAs 20-22) and one for the south (CFAs 23-24), because we currently believe that ENS is comprised of only these two main biological concentrations.
- The management areas do not reflect biological distribution of the resource and compromise reliability of the biomass estimates.
- The biomass estimates presented in this document, are believed to be a fair reflection of the real biomass, at the time of the survey and with our current knowledge.
- There is still major concerns that remains to be investigated such as; mortality/loss rate, temperature factor, magnitude of movement from year to year, or what happened to the recruitment in 1999?
- In the mean time, we recommend to approach the management of the northern portion of ENS, as well as the "traditional" fishing grounds of CFA 23 and 24 in a very conservative manner.

A comprehensive and large-scale tagging study comparable to the one in the SGSL should be implemented as early as the spring of 2000 in ENS. It is important to understand the movement factor, if any, in ENS. What is the proportion, the magnitude of it! Is there difference between seasons, sexes, size-classes? Is the grounds used differently between seasons, sexes, size-classes? The relationship between snow crab and temperature must be investigated properly, and close cooperation with DFO-Hydrology Services and other expertise will be necessary to obtain the type of information that will be relevant for this assessment. Another study that needs to be carried is an in-depth investigation to establish a proper key for the relative carapace age determination for ENS fishery.

REFERENCES

Anonymous. 1994. General overview of Atlantic coast snow crab and report on the status of snow crab in the southern Gulf of St. Lawrence (Fishing areas 12,18,19 25 and 26). DFO Atlantic Fisheries Stock Status Rep. 94/1.

Anonymous, 1998. Limited effort snow crab fishery in the non-traditional grounds of CFAs 23 and 24. DFO Maritimes Regional Fisheries Status Report 98/6E, 5 pp.

Anonymous. 1999. The 1999 snow crab (*Chionoecetes opilio*) integrated fishery management plan / Plan de gestion intégrée de la pêche du crabe des neiges (*Chionoecetes opilio*) de 1998. Dept. of Fisheries and Oceans, Scotia-Fundy Fisheries, Maritime Region, Halifax, N.S.

Biron, M., M. Moriyasu, E. Wade, P. DeGrâce, R. Campbell and M. Hébert. 1998a. Assessment of the 1997 snow crab (*Chionoecetes opilio)* fisheries off eastern Nova Scotia (Areas 20 to 24, (and 4X)), Canada. Can. Stock Assess. Sec. Res. Doc., 98/101.

Biron, M., E. Wade and M. Moriyasu. 1998b. Evaluation of the possibility for effort increase in eastern Nova Scotia Snow crab fishing CFAs 23 and 24. Can. Stock Assessment Secretariat Res. Doc., 98/129.

Biron, M., M. Moriyasu, E. Wade, P. DeGrâce, R. Campbell and M. Hébert. 1999. Assessment of the 1998 snow crab (*Chionoecetes opilio)* fisheries off eastern Nova Scotia (Areas 20 to 24, (and 4X)), Canada. Can. Stock Assess. Sec. Res. Doc., 99/12.

Biron, M., R. Campbell and M. Moriyasu. 2000. Historical review (1994-1998) and assessment of the 1999 expioratory snow crab (*Chionoecetes opilio)* fishery off eastern Cape Breton, Nova Scotia (NAFO Division 4X). Can. Stock Assess. Sec. Res. Doc., 2000/018

CAFSAC, 1991. CAFSAC Invertebrates and Marine Plants Subcommittee Meeting of 26-28 November, 1991, St. John's NFLD. CAFSAC Invertebrates and Marine Plants Subcommittee report. 91/19.

Clark, I. 1979. Practical geostatistics. Elsvier Science Publications, London and New York. 129 p.

Conan, G.Y. 1985. Assessment of shellfish stock by geostatistical techniques. ICES Shellfish Comm. C.M. 1985/K:30.

Conan , G.Y. and M. Comeau. 1986. Functional maturity of male snow crab, (*Chionoecetes opilio*). Can. J. Fish. Aquat. Sci. 43 : 1710-1719.

Conan, G.Y., M. Comeau, C. Gosset, G. Robichaud and C. Garaïcoechea. 1994. The Bigouden Nephrops trawl, and the devismes trawl, two otter trawls efficiency catching benthic stages of snow crab (*Chionoecetes opilio*), and the american lobster (*Homarus americanus*). Can. Tech. Rep. Fish. Aquat. Sci. 1992.

Conan, G.Y., M. Moriyasu, E.Wade and M.Comeau. 1988. Assessment and spatial distribution surveys of snow crab stocks by geostatistics. ICES Shellfish Comm. C.M. 1988/K:10.

Drinkwater, K.F. 1998. Temperature conditions in the Gulf of St. Lawrence and on the Scotian Shelf during 1997 relevant to snow crab. DFO. Atlan. Fish. Res. Doc. 98/56.

Drinkwater, K.F., Petitpas, R., Petrie, L. and D.P. Swain. 1997. Temperature conditions in the Gulf of St. Lawrence and on the Scotian Shelf during 1996 relevant to snow crab. DFO Atlan. Fish. Res. Doc. 97/02.

Elner, R.W. and D.A. Robichaud. 1985. Assessment of the 1984 fishery for snow crab off the Atlantic coast of Cape Breton Island. Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC) Res. Doc. 85/5.

Elner, R.W. and D.A. Robichaud. 1987. Assessment of the 1986 fishery for snow crab, *Chionoecetes opilio*, off the Atlantic coast of Cape Breton Island. Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC) Res. Doc. 87/86.

Foyle, T.P., G.V. Hurley, and D.M. Taylor. 1989. Field testing shell hardness guages for the snow crab fishery. Can. Ind. Rep. Fish. Aquat. Sci. 193.

Hébert, A., E. Wade and M. Moriyasu. 1999. Review of catch and effort data for the snow crab *Chionoecetes opilio* fishery in the southern Gulf of St. Lawrence (CFAs 12-25/26) from 1989 to 1998. DFO. Atlan. Fish. Res. Doc. 99/xx (in preparation).

Hébert, M., C. Gallant, Y. Chiasson, P. Mallet, P. DeGrâce, et M. Moriyasu. 1992. Le suivi du pourcentage de crabes mous dans les prises commerciales de crabe des neiges (*Chionoecetes opilio*) dans le sud-ouest du golfe du Saint-Laurent (zone 12) en 1990 et 1991. Rapp. Tech. Can. Sci. Halieut. Aquat. 1886.

Matheron, G. 1970. La théorie des variables régionalisées et ses applications. Les Cahiers du Centre de Morphologie Mathématique de Fontainebleau. Fascicule 5. 221 p.

Sainte-Marie, B., S. Raymond and J.-C. Brêthes. 1995. Growth and maturation of the benthic stages of male snow crab, Chionoecetes opilio (Brachyura: Majidae). Can. J. Fish. Aquat. Sci. 52: 903-924.

Squires, H.J. 1990. Decapod Crustacea of the Atlantic Coast of Canada. Can. Bull. Fish Aquat. Sci. 221: 532p.

Tremblay, M.J. and M.D. Eagles. 1995. Assessment of the 1994 snow crab fishery off eastern Cape Breton (CFAs 20-24). DFO Atlantic Fish. Res. Doc. 95/1.

Tremblay, M.J. and M.D. Eagles. 1996. Assessment of the 1995 snow crab fishery off eastern Nova Scotia. DFO Atlantic Fish. Res. Doc. 96/xx.

Tremblay, M.J., M.D. Eagles and R.W. Elner. 1994. Catch, effort and population structure in the snow crab fishery off eastern Cape Breton, 1978-1993: a retrospective. Can. Tech. Rep. Fish. Aquat. Sci. 2021.

Table 1. Summary of the Management Plan measures for 1999.[1]

Area	Season	Regular licenses	Traps allowed	Quota per regular licenses (kg)		Temporary permits	Traps allowed	Total quota temporary permits (kg)
				per license	Area total			
20	July 22- Sept. 15	5	30	11,340	56,700	4	30	33,900
21	July 22- Sept. 15	32	25	9,072	290,300	none	none	none
22	Northern group:[2]							
	July 22- Sept. 15	23	30	13,154	302,550	none	none	none
	Southern group:[2]							
	July 22- Sept. 15	14	30	15,422	215,910	none	none	none
23	July 25- Sept 25	24	30	37,500	900,000	13	30	400,000
24	Aug.1st - Sept. 30	23	40	35,870	825,000	22	40	575,000

[1] Information from Integrated fishery management plan (Anonymous, 1999a)
[2] Both groups have agreed not to fish on Sundays.

Table 2. Landings of snow crab (*Chionoecetes opilio)* for eastern Nova Scotia (Areas 20 to 24), 1978 - 1999.

Year	Active licenses/permits	Logbooks received	Landing Statistics (t)	Total mean CPUE (kg/trap haul)	Total Effort (1000's of trap hauls)
1978	42	42	801	28.4	28.2
1979	98	89	1,634	28.7	56.9
1980	99	81	819	19.8	41.4
1981	55	19	156	21.8	7.2
1982	67	56	554	16.7	33.2
1983	97	80	259	9.6	27.0
1984	51	38	124	8.6	14.4
1985	29	24	89	8.7	10.2
1986	29	23	120	10.2	11.8
1987	61	49	361	12.6	28.7
1988	88	74	596	14.6	40.8
1989	100	85	616	18.7	32.9
1990	102	87	1,152	25.4	45.4
1991	101	91	1,533	30.9	49.6
1992	104	77	1,797	32.5	55.3
1993	113	85	2,016	28.1	71.7
1994	117	83	1,551	21.2	73.2
1995	134	41	1,554	22.0	70.6
1996	124	124	1,491	29.6	50.3
1997	133	133	1,677	37.3	44.9
1998	141	140	2,238	58.0	38.6
1999			3,598	66.2	54.4
Average (all)			1,124	25.0	40.3
Average (96-99)			2,251	47.8	47.1

Table 3. Landings, catch rate and effort statistics for snow crab Area 20, 1978 - 1999.

Year	Active boats	Logbooks received	Landing statistics (t)	Mean CPUE (kg/trap haul)	Total Effort (1000's of trap hauls)
1978	-	0	61	-	-
1979	8	3	80	8.2	9.8
1980	8	3	34	8.3	4.1
1981	6	0	2	-	-
1982	-	0	2	-	-
1983	12	2	23	1.7	13.5
1984	2	0	10	-	-
1985	1	0	1	-	-
1986	2	1	0	1.9	-
1987	3	0	1	-	-
1988	4	2	17	7.9	2.2
1989	5	0	8	-	-
1990	4	2	5	5.3	0.9
1991	4	3	14	16.3	0.9
1992	3	3	18	40.6	0.4
1993	4	4	20	17.3	1.2
1994	5	4	29	20.2	1.4
1995	5	1	44	19.8	2.2
1996	5	5	43	14.7	2.9
1997	5	5	45	20.2	2.3
1998	5	4	45	35.5	1.3
1999	9	9	90	32.3	2.8
average (all)			26.9	16.7	3.3
average (96-99)			57.5	25.7	2.3

Table 4. Weekly landings, catch rate and effort statistics for snow crab Area 20 in 1999.

a) Weekly landings statistics

week	landings (kg)		
	all	permanent	temporary
July 25	27,153	18,785	8,368
Aug. 01	35,290	18,625	16,665
Aug. 08	13,171	7,352	5,819
Aug. 15	11,072	8,638	2,434
Aug. 22	4,370	3,854	516
total[2]	90,215	56,390	33,825

b) Weekly catch rate statistics

week	CPUE (kg/trap haul)		
	all	permanent	temporary
July 25	38.6	39.3	37.2
Aug. 01	32.1	28.6	37.2
Aug. 08	26.7	23.6	31.8
Aug. 15	27.6	30.9	18.2
Aug. 22	35.8	42.8	16.1
total[2]	32.3	31.6	33.7

c) Weekly effort statistics

week	Effort (total number of traps hauls)		
	all	permanent	temporary
July 25	703	478	225
Aug. 01	1,100	652	448
Aug. 08	494	311	183
Aug. 15	401	280	134
Aug. 22	122	90	32
total[2]	2,793	1,784	1,004

[2] Total seasonal landings.

Table 5. Seasonal catch composition, in percentage, from at-sea samples for eastern Nova Scotia in 1999.

a) Catch composition in Area 20 (%).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
3	9	< 95 mm	1.12	5.31	0.00	0.00	1.12	5.31	6.42
		> 95 mm	3.91	83.80	0.00	5.87	3.91	89.66	93.58
		total	5.03	89.11	0.00	5.87	5.03	94.97	100.00

b) Catch composition in Area 21 (%).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
10	36	< 95 mm	0.92	7.01	0.42	0.21	1.34	7.22	8.56
		> 95 mm	6.30	75.09	1.70	8.35	8.00	83.44	91.44
		total	7.22	82.09	2.12	8.56	9.34	90.66	100.00

c) Catch composition in Area 22 (%).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
16	94	< 95 mm	2.75	13.23	1.66	0.44	4.40	13.67	18.07
		> 95 mm	5.14	63.18	2.20	11.41	7.34	74.59	81.93
		total	7.88	76.41	3.86	11.85	11.74	88.26	100.00

d) Catch composition in Area 23 (%).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
27	223	< 95 mm	2.66	14.94	1.51	0.99	4.17	15.93	20.10
		> 95 mm	2.82	73.18	0.75	3.14	3.57	76.33	79.90
		total	5.48	88.12	2.26	4.14	7.74	92.23	100.00

e) Catch composition in Area 24 (%).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
37	245	< 95 mm	3.70	13.15	1.94	0.80	5.64	13.94	19.58
		> 95 mm	5.27	68.91	1.56	4.69	6.82	73.60	80.42
		total	8.96	82.05	3.50	5.49	12.46	87.54	100.00

Table 6. Seasonal catch composition, in number, from at-sea samples for eastern Nova Scotia (Areas 20 – 24) in 1999.

a) Catch composition in Area 20 (in number).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
3	9	< 95 mm	4	19	0	0	4	19	23
		> 95 mm	14	300	0	21	14	321	335
		total	18	319	0	21	18	340	358

b) Catch composition in Area 21 (in number).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
10	36	< 95 mm	13	99	6	3	19	102	121
		> 95 mm	89	1061	24	118	113	1179	1292
		total	102	1160	30	121	132	1281	1413

c) Catch composition in Area 22 (in number).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
16	94	< 95 mm	101	487	61	16	162	503	665
		> 95 mm	189	2325	81	420	270	2745	3015
		total	290	2812	142	436	432	3248	3680

d) Catch composition in Area 23 (in number).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
27	223	< 95 mm	236	1326	134	88	370	1414	1784
		> 95 mm	250	6495	67	279	317	6774	7091
		total	486	7821	201	367	687	8188	8875

e) Catch composition in Area 24 (in number).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
37	245	< 95 mm	349	1241	183	75	532	1316	1848
		> 95 mm	497	6504	147	443	644	6947	7591
		total	846	7745	330	518	1176	8263	9439

Table 7a. Seasonal catch composition, in percentage, from at-sea samples for eastern Nova Scotia in 1997.

a) Catch composition in Area 20 (%).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
2	11	< 95 mm	1.36	2.95	0.45	1.14	1.82	4.09	5.91
		> 95 mm	5.45	76.59	4.09	7.95	9.55	84.55	94.09
		total	6.82	79.55	4.55	9.09	11.36	88.64	100.00

b) Catch composition in Area 21 (%).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
1	6	< 95 mm	0.42	2.08	0.00	0.83	0.42	2.92	3.33
		> 95 mm	0.42	69.58	3.75	22.92	4.17	92.50	96.67
		total	0.83	71.67	3.75	23.75	4.58	95.42	100.00

c) Catch composition in Area 22 (%).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
16	99	< 95 mm	4.31	19.23	6.83	3.54	11.15	22.78	33.92
		> 95 mm	6.39	32.41	8.35	18.93	14.74	51.34	66.08
		total	10.71	51.64	15.18	22.47	25.89	74.11	100.00

d) Catch composition in Area 23 (%).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
33	224	< 95 mm	3.81	24.37	6.33	3.58	10.14	27.95	38.09
		> 95 mm	7.01	43.80	3.74	7.36	10.75	51.16	61.91
		total	10.83	68.17	10.06	10.94	20.89	79.11	100.00

e) Catch composition in Area 24 (%).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
25	180	< 95 mm	1.57	17.70	6.07	1.91	7.64	19.61	27.25
		> 95 mm	2.06	60.72	2.49	7.47	4.55	68.20	72.75
		total	3.63	78.43	8.56	9.38	12.19	87.81	100.00

Table 7b. Seasonal catch composition, in number, from at-sea samples for eastern Nova Scotia (Areas 20 – 24) in 1997.

a) Catch composition in Area 20 (in number).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
2	11	< 95 mm	6	13	2	5	8	18	26
		> 95 mm	24	337	18	35	42	372	414
		total	30	350	20	40	50	390	440

b) Catch composition in Area 21 (in number).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
1	6	< 95 mm	1	5	0	2	1	7	8
		> 95 mm	1	167	9	55	10	222	232
		total	2	172	9	57	11	229	240

c) Catch composition in Area 22 (in number).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
16	99	< 95 mm	168	749	266	138	434	887	1321
		> 95 mm	249	1262	325	737	574	1999	2573
		total	417	2011	591	875	1008	2886	3894

d) Catch composition in Area 23 (in number).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
33	224	< 95 mm	340	2172	564	319	904	2491	3395
		> 95 mm	625	3904	333	656	958	4560	5518
		total	965	6076	897	975	1862	7051	8913

e) Catch composition in Area 24 (in number).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
25	180	< 95 mm	113	1272	436	137	549	1409	1958
		> 95 mm	148	4363	179	537	327	4900	5227
		total	261	5635	615	674	876	6309	7185

Table 8a. Seasonal catch composition, in percentage, from at-sea samples for eastern Nova Scotia in 1998.

a) Catch composition in Area 20 (%).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
4	23	< 95 mm	0.65	4.18	0.26	0.13	0.92	4.31	5.23
		> 95 mm	3.14	78.17	4.18	9.28	7.32	87.45	94.77
		total	3.79	82.35	4.44	9.41	8.24	91.76	100.00

b) Catch composition in Area 21 (%).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
3	17	< 95 mm	1.03	6.33	1.77	0.15	2.80	6.48	9.28
		> 95 mm	4.86	64.06	6.33	15.46	11.19	79.53	90.72
		total	5.89	70.40	8.10	15.61	13.99	86.01	100.00

c) Catch composition in Area 22 (%).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
0	0	< 95 mm	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		> 95 mm	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		total	N/A	N/A	N/A	N/A	N/A	N/A	N/A

d) Catch composition in Area 23 (%).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
14	132	< 95 mm	1.91	18.14	1.32	1.18	3.23	19.32	22.55
		> 95 mm	4.53	67.08	1.51	4.33	6.03	71.41	77.45
		total	6.43	85.22	2.83	5.52	9.26	90.74	100.00

e) Catch composition in Area 24 (%).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
16	101	< 95 mm	2.33	24.59	2.68	4.15	5.00	28.74	33.74
		> 95 mm	1.58	49.05	3.50	12.13	5.08	61.18	66.26
		total	3.90	73.64	6.18	16.28	10.08	89.92	100.00

Table 8b. Seasonal catch composition, in number, from at-sea samples for eastern Nova Scotia (Areas 20 – 24) in 1998.

a) Catch composition in Area 20 (in number).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
4	23	< 95 mm	5	32	2	1	7	33	40
		> 95 mm	24	598	32	71	56	669	725
		total	29	630	34	72	63	702	765

b) Catch composition in Area 21 (in number).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
3	17	< 95 mm	7	43	12	1	19	44	63
		> 95 mm	33	435	43	105	76	540	616
		total	40	478	55	106	95	584	679

c) Catch composition in Area 22 (in number).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
0	0	< 95 mm	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		> 95 mm	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		total	N/A	N/A	N/A	N/A	N/A	N/A	N/A

d) Catch composition in Area 23 (in number).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
14	132	< 95 mm	100	950	69	62	169	1012	1181
		> 95 mm	237	3513	79	227	316	3740	4056
		total	337	4463	148	289	485	4752	5237

e) Catch composition in Area 24 (in number).

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
16	101	< 95 mm	93	983	107	166	200	1149	1349
		> 95 mm	63	1961	140	485	203	2446	2649
		total	156	2944	247	651	403	3595	3998

Table 9. Landings, catch rate and effort statistics for snow crab Area 21, 1978 - 1999.

Year	Active licenses	Logbooks received	Landing statistics (t)	Mean CPUE (kg/trap haul)	Total Effort (1000's of trap hauls)
1978	16	16	247	11.3	21.9
1979	27	27	243	10.7	22.7
1980	31	25	153	9.7	15.8
1981	22	1	34	13.6	2.5
1982	20	18	94	7.9	11.9
1983	27	25	48	5.1	9.4
1984	19	13	18	2.9	6.2
1985	10	7	10	3.5	2.9
1986	12	8	7	2.5	2.8
1987	21	15	56	6.4	8.8
1988	24	19	125	9.6	13.0
1989	30	27	154	13.7	11.2
1990	31	27	167	13.1	12.7
1991	29	27	157	14.9	10.5
1992	31	28	196	16.7	11.7
1993	30	28	168	14.2	11.8
1994	31	29	107	7.2	14.9
1995	32	7	100	8.3	12.0
1996	32	32	136	9.7	13.9
1997	32	32	146	35.7	4.1
1998	32	32	216	53.0	4.1
1999	32	32	291	62.1	4.7
average (all)			131	15.1	10.4
average (95-98)			197	40.1	6.7

Table 10. Weekly landings, catch rate and effort statistics for snow crab Area 21, 1999.

week	landings (kg)	CPUE (kg/trap haul)	Effort (total number of trap hauls)
July 18	115,665	87.5	1,321
July 25	119,395	64.3	1,857
Aug. 01	45,216	39.8	1,136
Aug. 08	9,817	30.4	323
Aug. 15	500	23.8	21
Aug. 22	563	31.3	18
total[1]	290.705	62.1	4,681

[1] Total seasonal landings and seasonal CPUE were used to obtain these results.

Table 11. Landings, catch rate and effort statistics for snow crab Area 22, 1978 - 1999.

Year	Active licenses	Logbooks received	Landing statistics (t)	Mean CPUE (kg/trap haul)	Total Effort (1000's of trap hauls)
1978	15	14	341	28.9	11.8
1979	35	35	684	38.4	17.8
1980	26	24	227	21.0	10.8
1981	11	3	50	12.5	4.0
1982	21	14	153	19.6	7.8
1983	26	21	52	8.5	6.1
1984	7	7	18	8.6	2.1
1985	8	7	3	6.0	0.5
1986	5	3	18	10.0	1.8
1987	16	14	63	10.5	6.0
1988	29	22	114	10.4	11.0
1989	26	20	93	15.0	6.2
1990	26	21	119	9.0	13.2
1991	24	23	183	18.5	9.9
1992	27	15	240	24.2	9.9
1993	40	27	390	21.0	18.6
1994	38	28	259	12.0	21.6
1995	37	11	284	9.7	29.3
1996	37	37	189	10.3	18.3
1997	37	37	343	20.8	16.5
1998	37	37	396	38.2	10.4
1999	37	37	517	58.5	8.8
average (all)			215	18.7	11.0
average (96-99)			361	32.0	13.5

Table 12. Weekly landings, catch rate and effort statistics for snow crab Area 22, 1999.

a) Weekly landings statistics

week	landings (kg)		
	all	northern	outer area
July 18	178,562	115,159	63,403
July 25	231,478	115,797	115,681
Aug.01	107,175	70,614	36,561
Aug.08	2,183	2,183	
total[1]	517,199	302,501	214,698

b) Weekly catch rate statistics

week	CPUE (kg/trap haul)		
	all	northern	outer area
July 18	80.2	76.9	88.1
July 25	57.5	52.2	63.6
Aug.01	42.3	39.7	48.4
Aug.08	21.2	21.2	-
total[1]	58.5	54.1	65.7

c) Weekly effort statistics

week	Effort (total number of traps hauls)		
	all	northern	outer area
July 18	2,214	1,498	720
July 25	4,024	2,217	1,820
Aug.01	2,536	1,777	755
Aug.08	103	103	-
total[1]	8,841	5,592	3,283

[1] Total seasonal landings.

Table 13. Comparison of the seasonal catch composition from at-sea samples between northern and outer fishing grounds for Area 22 in 1999.

a) Catch composition in percentage of northern fishing grounds.

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
12	70	< 95 mm	1.39	7.30	1.32	0.15	2.72	7.45	10.17
		> 95 mm	5.39	67.38	2.61	14.46	8.00	81.83	89.83
		total	6.79	74.68	3.93	14.61	10.72	89.28	100.00

b) Catch composition in number of northern fishing grounds.

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
12	70	< 95 mm	38	199	36	4	74	203	277
		> 95 mm	147	1836	71	394	218	2230	2448
		total	185	2035	107	398	292	2433	2725

c) Catch composition in percentage of outer fishing grounds.

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
4	24	< 95 mm	6.60	30.16	2.62	1.26	9.21	31.41	40.63
		> 95 mm	4.40	51.20	1.05	2.72	5.45	53.93	59.37
		total	10.99	81.36	3.66	3.98	14.66	85.34	100.00

d) Catch composition in number of outer fishing grounds.

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
4	24	< 95 mm	63	288	25	12	88	300	388
		> 95 mm	42	489	10	26	52	515	567
		total	105	777	35	38	140	815	955

Table 14. Landings, catch rate and effort statistics for snow crab in Area 23, 1978 - 1999.

Year	Active licenses/permits	Logbooks received	Landing statistics (t)	Mean CPUE (kg/trap haul)	Total Effort (1000's of trap hauls)
1978	-	15	347	51.5	6.7
1979	-	22	608	43.4	14.0
1980	-	21	343	39.0	8.8
1981	-	10	82	26.5	3.1
1982	-	21	253	28.8	8.8
1983	-	26	119	16.5	7.2
1984	-	7	41	18.6	2.2
1985	5	5	28	14.7	1.9
1986	6	6	49	14.4	3.4
1987	14	11	157	26.2	6.0
1988	21	18	207	24.9	8.3
1989	25	23	243	28.3	8.6
1990	27	24	386	36.4	10.6
1991	23	22	528	44.8	11.8
1992	22	18	595	49.6	12.0
1993	26	16	770	53.1	14.5
1994	22	22	497	33.4	14.9
1995	31	7	576	51.8	11.1
1996	27	27	564	65.6	8.6
1997	30	30	592	57.8	10.2
1998	34	34	813	77.0	10.6
1999			1,300	87.3	14.9
average (all)			414	40.4	9.0
average (96-99)			817	71.9	11.1

Table 15. Weekly landings, catch rate and effort statistics for snow crab Area 23 in 1999.

a) Weekly landings statistics

week	landings (kg)			
	all	permanent	temporary	
			c	d
July 25	176,501	159,731	11,150	5,620
Aug. 01	327,102	268,877	32,978	25,247
Aug. 08	194,249	141,999	40,924	11,326
Aug. 15	196,017	146,981	42,272	6,724
Aug. 22	218,583	111,638	76,094	30,851
Aug. 29	90,759	44,503	36,634	9,622
Sept. 05	41,997	13,530	22,715	5,752
Sept. 12	35,964	5,456	25,583	4,925
Sept. 19	10,743	3,880	6,863	-
Sept. 26	3,828	2,172	1,656	-
total[2]	1,299,716	900,057	299,535	100,124

b) Weekly catch rate statistics

week	CPUE (kg/trap haul)			
	all	permanent	temporary	
			c	d
July 25	104.0	107.1	69.7	122.2
Aug. 01	103.3	105.3	73.6	154.9
Aug. 08	91.9	108.6	58.7	110.0
Aug. 15	81.7	81.5	78.7	112.7
Aug. 22	80.7	79.2	76.4	101.5
Aug. 29	65.0	65.3	58.5	109.3
Sept. 05	76.1	63.4	76.2	122.4
Sept. 12	63.8	55.7	59.5	136.8
Sept. 19	65.9	80.8	59.7	-
Sept. 26	42.5	47.2	37.6	-
total[2]	87.3	93.3	68.2	118.2

c) Weekly effort statistics

week	Effort (total number of traps hauls)			
	all	permanent	temporary	
			c	d
July 25	1,697	1,491	160	46
Aug. 01	3,166	2,554	448	163
Aug. 08	2,114	1,307	697	103
Aug. 15	2,400	1,803	537	60
Aug. 22	2,709	1,410	996	304
Aug. 29	1,396	682	626	88
Sept. 05	552	213	298	47
Sept. 12	564	98	430	36
Sept. 19	163	48	115	-
Sept. 26	90	46	44	-
total[2]	14,888	9,647	4,392	847

[1] Including landings from July 25+26 [2] Total seasonal landings.

Table 16. Breakdown of the seasonal landings, catch rate and effort statistic for snow crab in the sub-areas of CFAs 23 and 24 in 1999.

sub-area	Landing Statistics (t)	averaged Seasonal CPUE (kg/trap haul)	Total Effort (1000's of trap hauls)
Area 23:			
A	714,285	89.1	8,017
B	185,772	114.2	1,627
C	299,535	68.2	4,392
D	100,124	118.2	847
Total Area 23	*1,299,716*	*87.3*	*14,888*
Area 24:			
A	536,808	64,2	8,362
B	363,599	67.9	5,355
-perm.	288,542	64.8	4,453
-temp.	75,057	83.4	900
C	300,500	56.9	5,281
D	100,090	69.5	1,440
E	99,495	38,0	2,618
Total Area 24	*1,400,492*	*60,6*	*23,110*

Table 17. Comparison of the seasonal catch composition from at-sea samples between traditional and non-traditional fishing grounds for Area 23 in 1999.

a) Catch composition in percentage of traditional fishing grounds.

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
18	113	< 95 mm	2.63	19.80	2.05	1.65	4.68	21.45	26.14
		> 95 mm	2.90	65.43	0.96	4.57	3.86	70.00	73.86
		total	5.53	85.24	3.01	6.22	8.54	91.46	100.00

b) Catch composition in number of traditional fishing grounds.

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
18	113	< 95 mm	118	888	92	74	210	962	1172
		> 95 mm	130	2934	43	205	173	3139	3312
		total	248	3822	135	279	383	4101	4484

c) Catch composition in percentage of non-traditional fishing grounds; sub-area 23C.

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
7	83	< 95 mm	3.20	12.08	0.36	0.03	3.56	12.11	15.68
		> 95 mm	2.96	80.88	0.27	0.21	3.23	81.09	84.32
		total	6.16	92.96	0.63	0.24	6.80	93.20	100.00

d) Catch composition in number of non-traditional fishing grounds; sub-area 23C.

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
7	83	< 95 mm	106	400	12	1	118	401	519
		> 95 mm	98	2678	9	7	107	2685	2792
		total	204	3078	21	8	225	3086	3311

e) Catch composition in percentage of non-traditional fishing grounds; sub-area 23D.

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
2	27	< 95 mm	1.11	3.52	2.78	1.20	3.89	4.72	8.61
		> 95 mm	2.04	81.76	1.39	6.20	3.43	87.96	91.39
		total	3.15	85.28	4.17	7.41	7.31	92.69	100.00

f) Catch composition in number of non-traditional fishing grounds; sub-area 23D.

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
2	27	< 95 mm	12	38	30	13	42	51	93
		> 95 mm	22	883	15	67	37	950	987
		total	34	921	45	80	79	1001	1080

Table 18. Landings, catch rate and effort statistics for snow crab Area 24, 1978 - 1999.

Year	Active licenses/permits	Logbooks received	Landing statistics	Mean CPUE (kg/trap haul)	Total Effort (1000's of trap hauls)
1978	-	-	-	-	-
1979	4	4	61	14.8	4.1
1980	10	10	70	12.8	5.5
1981	5	5	21	15.8	1.3
1982	7	7	62	10.1	6.1
1983	13	11	64	8.4	7.6
1984	13	12	52	9.2	5.6
1985	6	5	35	10.2	3.4
1986	7	5	49	11.9	4.1
1987	11	9	84	12.9	6.5
1988	13	13	163	15.7	10.4
1989	18	17	201	17.2	11.7
1990	19	18	543	33.3	16.3
1991	21	16	682	40.1	17.0
1992	22	14	743	38.5	19.3
1993	21	17	662	33.3	19.9
1994	21	21	682	33.4	20.4
1995	31	8	550	34.4	16.0
1996	27	27	560	57.1	9.8
1997	29	29	565	45.2	12.5
1998	33	33	745	62.0	12.0
1999			1,400	60.6	22.9
average (all)			381	27.5	11.3
average (96-99)			818	56.2	14.4

Table 19. Weekly landings, catch rate and effort statistics for snow crab Area 24 in 1999.

a) Weekly landings statistics

week	landings (kg)			
	all	permanent	temporary	
			bcd	e
Aug. 01	268,059	216,931	51,128	-
Aug. 08	204,994	143,266	57,458	4,270
Aug. 15	262,292	178,205	79,667	4,420
Aug. 22	242,494	136,871	96,400	9,223
Aug. 29	181,745	86,034	86,254	9,457
Sept. 05	102,407	40,335	43,327	18,745
Sept. 12	54,543	10,788	28,744	15,011
Sept. 19	22,566	3,355	8,339	10,872
Sept. 26	39,262	6,487	16,431	16,344
Oct. 03	10,553	-	1,0005	9,548
Oct. 10	749	-	-	749
total[2]	1,389,664	825,350	475,647	99,495

b) Weekly catch rate statistics

week	CPUE (kg/trap haul)			
	all	permanent	temporary	
			bcd	e
Aug. 01	72.4	74.7	64.1	-
Aug. 08	70.4	79.4	59.4	28.7
Aug. 15	56.2	61.9	53.3	14.9
Aug. 22	57.9	61.5	56.4	37.2
Aug. 29	54.0	52.3	64.9	25.6
Sept. 05	54.7	47.6	71.0	45.3
Sept. 12	55.1	44.0	83.7	40.6
Sept. 19	55.7	44.7	75.1	49.6
Sept. 26	63.3	37.3	110.2	55.2
Oct. 03	45.1	-	41.9	45.5
Oct. 10	34.0	-	-	34.0
total[2]	60.6	64.4	62.2	38.0

c) Weekly effort statistics

week	Effort (total number of traps hauls)			
	all	permanent	temporary	
			bcd	e
Aug. 01	3,705	2,905	798	-
Aug. 08	2,913	1,804	967	149
Aug. 15	4,663	2,878	1,494	297
Aug. 22	4,186	2,226	1,709	248
Aug. 29	3,369	1,644	1,330	369
Sept. 05	1,871	848	610	414
Sept. 12	990	245	343	370
Sept. 19	405	75	111	219
Sept. 26	620	174	149	296
Oct. 03	234	-	24	210
Oct. 10	22	-	-	22
total[2]	23,110	12,816	7,647	2,618

[1] Including landings from July 25+26

[2] Total seasonal landings.

Table 20. Comparison of the seasonal catch composition from at-sea samples between permanent and temporary status for Area 24 in 1999.

a) Catch composition in percentage of permanent fishermen.

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
23	164	<95 mm	4.61	15.93	2.45	0.70	7.06	16.63	23.69
		>95 mm	5.56	63.15	2.00	5.61	7.56	68.75	76.31
		total	10.17	79.08	4.45	6.31	14.62	85.38	100.00

b) Catch composition in number of permanent fishermen.

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
23	164	<95 mm	295	1020	157	45	452	1065	1517
		>95 mm	356	4044	128	359	484	4403	4887
		total	651	5064	285	404	936	5468	6404

c) Catch composition in percentage of temporary fishermen; sub-areas 24B, 24C and 24D.

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
11	65	<95 mm	1.58	5.75	0.92	1.17	2.50	6.92	9.42
		>95 mm	5.13	81.19	0.75	3.50	5.88	84.70	90.58
		total	6.71	86.95	1.67	4.67	8.38	91.62	100.00

d) Catch composition in number of temporary fishermen; sub-areas 24B, 24C and 24D.

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
11	65	<95 mm	38	138	22	28	60	166	226
		>95 mm	123	1947	18	84	141	2031	2172
		total	161	2085	40	112	201	2197	2398

e) Catch composition in percentage of non-traditional fishing grounds; sub-area 24E.

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
3	16	<95 mm	2.51	13.03	0.63	0.31	3.14	13.34	16.48
		>95 mm	2.83	80.53	0.16	0.00	2.98	80.53	83.52
		total	5.34	93.56	0.78	0.31	6.12	93.88	100.00

f) Catch composition in number of non-traditional fishing grounds; sub-area 24E.

Coverage		Size	Hard shell crab		Soft shell crab		By maturity stage		Total
trip	trap		small claw	large claw	small claw	large claw	small claw	large claw	
3	16	<95 mm	16	83	4	2	20	85	105
		>95 mm	18	513	1	0	19	513	532
		total	34	596	5	2	39	598	637

Table 21. Composition and surface covered by different sediment types in the surveyed area in 1999.

Sediment types	Description / composition	Surface of surveyed area covered by sediment (%)
Sable Island sand and gravel	Sand with less than 50% gravel.	54%
LaHave clay	Silty clay, silty sandy clay and clayey sandy silt gracing locally to silty clayey sand (more than 20% sand).	10%
Sambro sand	Mainly silty and clayey sand with gravel.	27%
Emerald silt	Poorly sorted clayey and sandy silt (gravel may be present).	5%
Scotian Shelf drift	Glacial till, may include some stratified drift.	4%
Bedrock "type 5"	Grey siltstone and mud stone with thinner intervals of glauconitic sandstone.	(cross-section only)
Bedrock "type 4"	Argillaceous sandstone shale, siltstone, conglomerate and limestone.	(cross-section only)
Bedrock "type 3"	Undifferentiated sedimentary rocks.	(cross-section only)
Bedrock "type 2"	Conglomerate and sandstone, shale, coal, and minor limestone.	(cross-section only)
Acoustic basement	Includes Precambrian to Devonian volcanic, sedimentary, high grade metamorphic and granitic rocks.	(cross-section only)

Table 22. Biomass estimates (t) of male snow crab >95 mm in northern ENS.

Estimates for the Original Surveyed Area since 1997.

Year	R-1		B (fishable)		B (total)	
	(t)	c int	(t)	c int	(t)	c int
1997	-	-	-	-	-	-
1998	8,210	26%	1,510	215%	9,670	35%
1999	1,201	106%	1,211	133%	2,384	90%

Estimate for the Total Surveyed Area for that given year.

Year	R-1		B (fishable)		B (total)	
	(t)	c int	(t)	c int	(t)	c int
1997*	369	170%	213	193%	536	127%
1998	8,210	26%	1,510	215%	9,670	35%
1999	1,201	106%	1,211	133%	2,384	90%

*Survey covered CFA-22 only in 1997

R-1: CW > 95 mm adult of carapace condition 1 and 2 at the time of the survey.
B (fishable): CW > 95 mm adult of carapace condition 3, 4 and 5 at the time of the survey.
B (total): CW > 95 mm adult at the time of the survey.

Table 23. Biomass estimates (t) of male snow crab >95 mm in southern ENS.

Estimates for the Original Surveyed Area since 1997.

Year	R-1		B (fishable)		B (total)	
	(t)	c int	(t)	c int	(t)	c int
1997*	10,335	49.6%	12,657	51.5%	19,468	44.1%
1998*	1,362	535.9%	23,510	47.7%	30,006	40.1%
1999	8,118	57.8%	17,056	34.9%	24,252	32.0%

*In 1997 and 1998, the originally surveyed area had 26 stations less compared to 1999

Estimate for the Total Surveyed Area for that given year.

Year	R-1		B (fishable)		B (total)	
	(t)	c int	(t)	c int	(t)	c int
1997	10,335	49.6%	12,657	51.5%	19,468	44.1%
1998	1,415	291.3%	24,880	48.3%	30,897	42.6%
1999	8,624	64.6%	23,533	33.4%	31,856	33.5%

R-1: CW > 95 mm adult of carapace condition 1 and 2 at the time of the survey.
B (fishable): CW > 95 mm adult of carapace condition 3, 4 and 5 at the time of the survey.
B (total): CW > 95 mm adult at the time of the survey.

Table 24. Exploitable biomass (t) available for 2000 fishery and proportion by fishing grounds.

Areas	Exploitable biomass (t)	Traditional grounds (%)	Non-traditional grounds (%)
20	-	8.6	-
21	-	43.8	-
22	-	47.6	-
Total	1,477	100.0	-
23	-	38.9	21.6*
24	-	38.4	1.0**
Total	29,322	77.3	22.7

*23CD; ** 24C

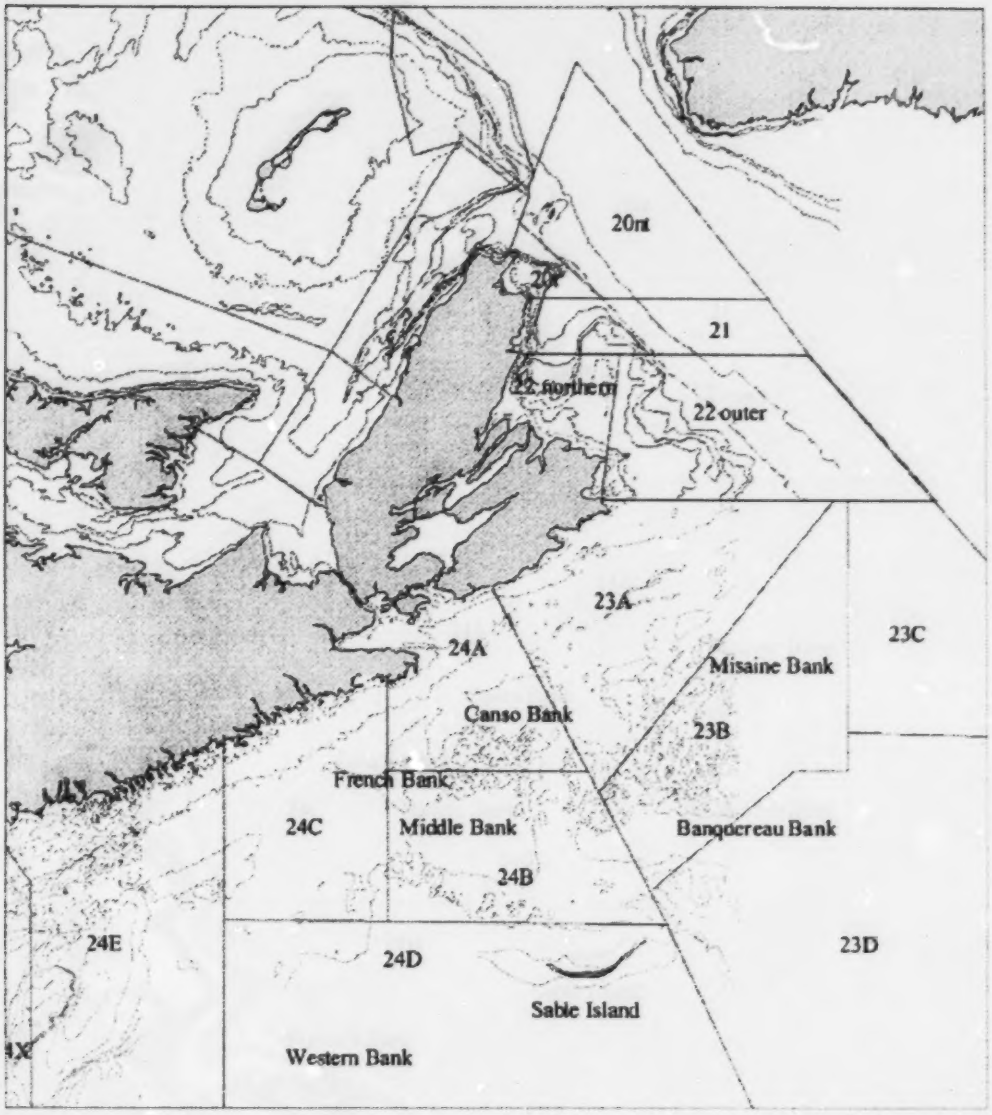

Figure 1. Snow crab management sub-areas off eastern Nova Scotia.

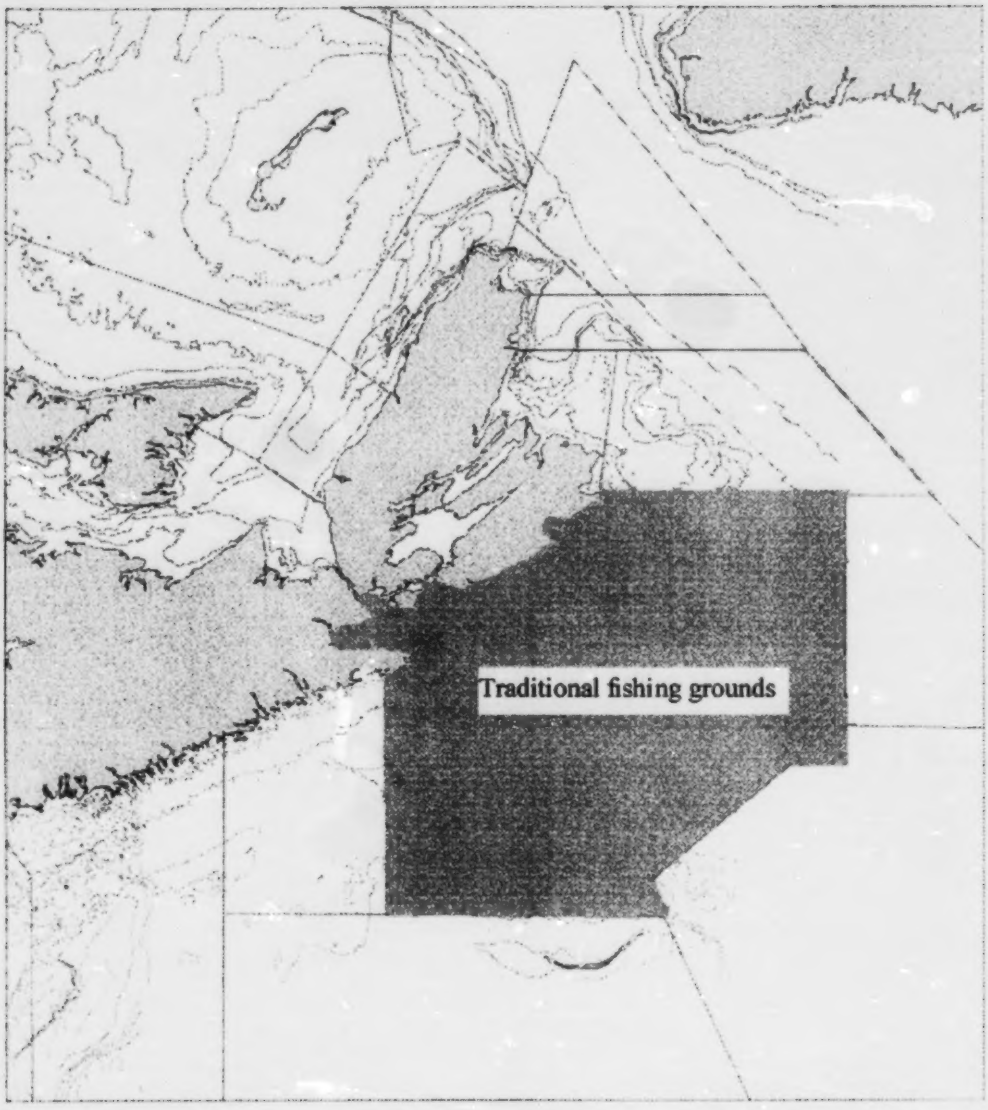

Figure 2. Traditional fishing grounds of CFAs 23 and 24.

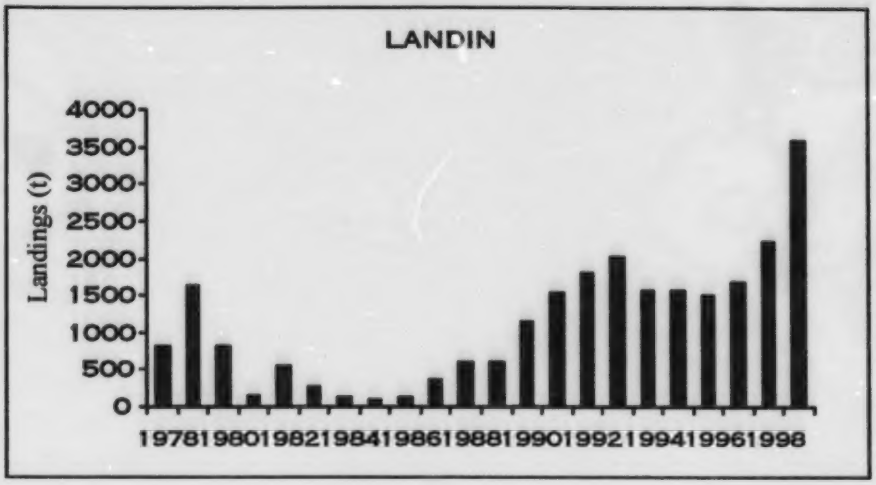

Figure 3. Snow crab landings (t) in eastern Nova Scotia from 1978 to 1999.

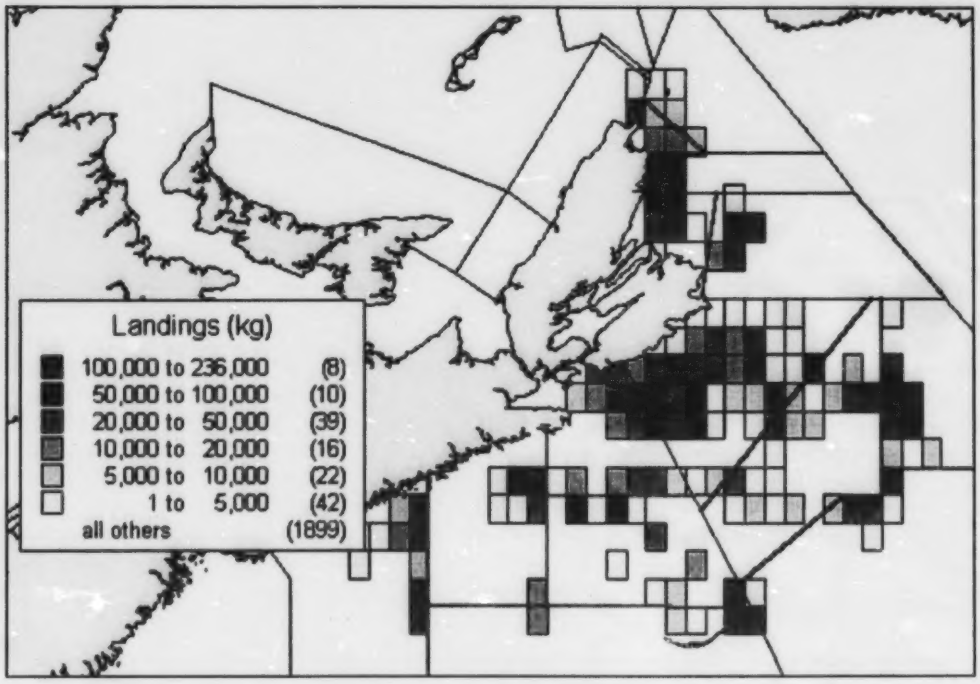

Figure 4. Seasonal distribution of snow crab landings (kg) in ENS in 1999.

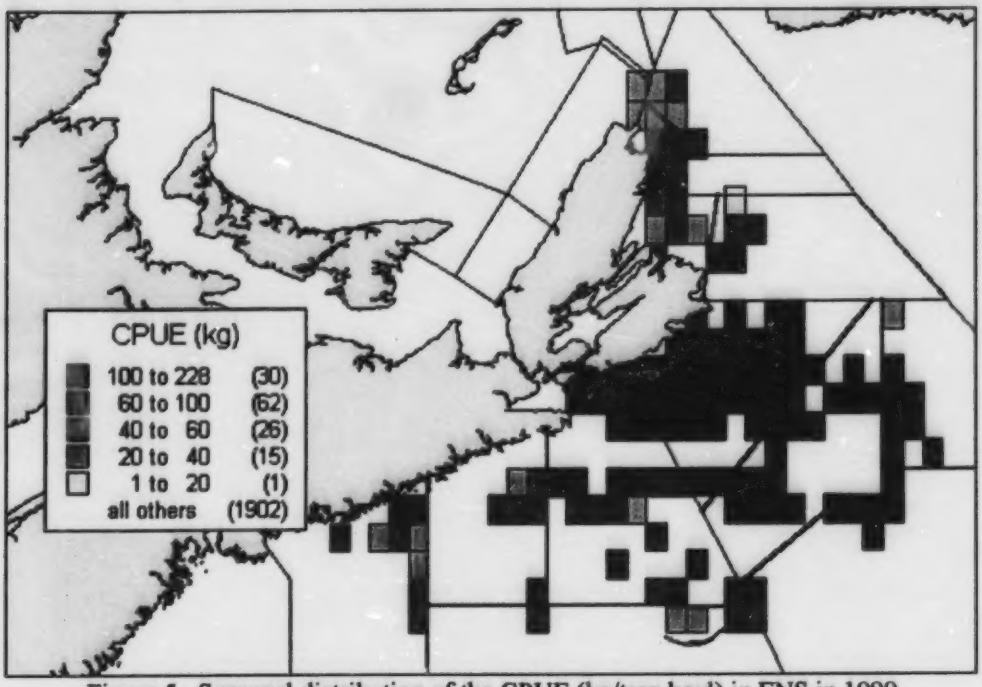

Figure 5. Seasonal distribution of the CPUE (kg/trap haul) in ENS in 1999.

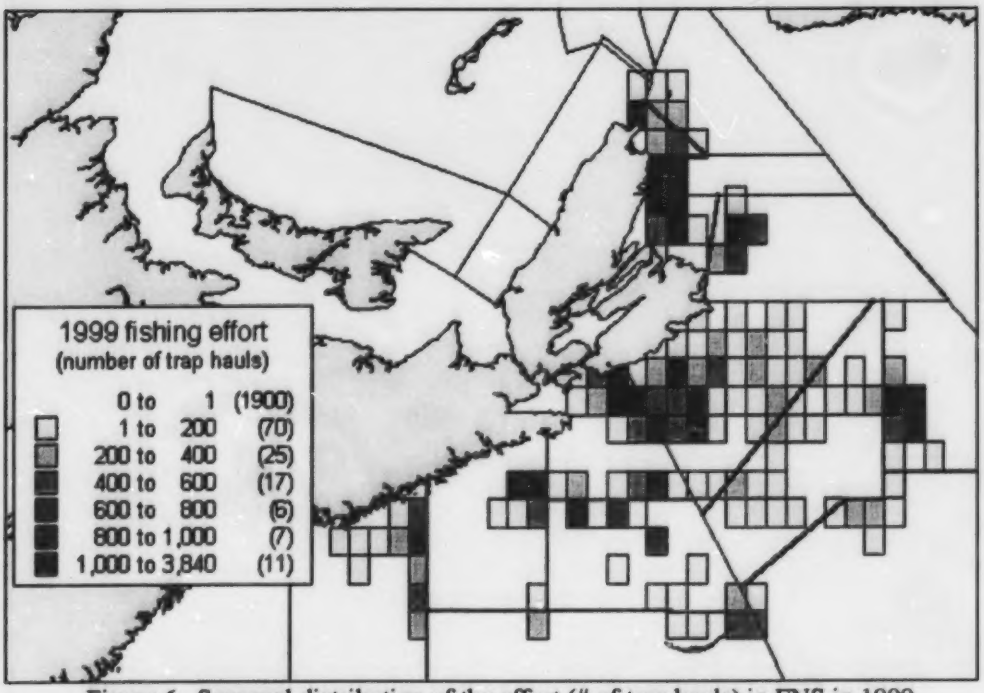

Figure 6. Seasonal distribution of the effort (# of trap hauls) in ENS in 1999.

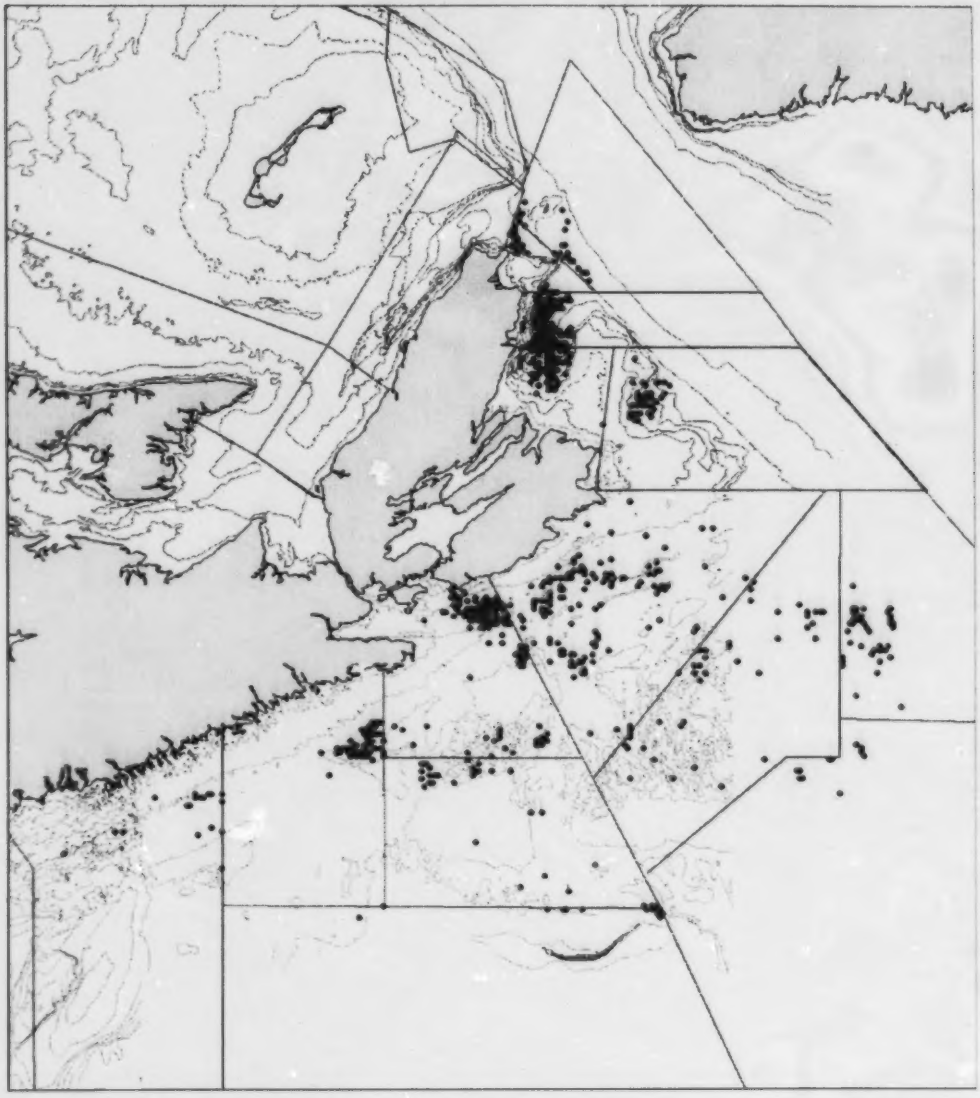

Figure 7. Reported logbook positions in eastern Nova Scotia in 1999.

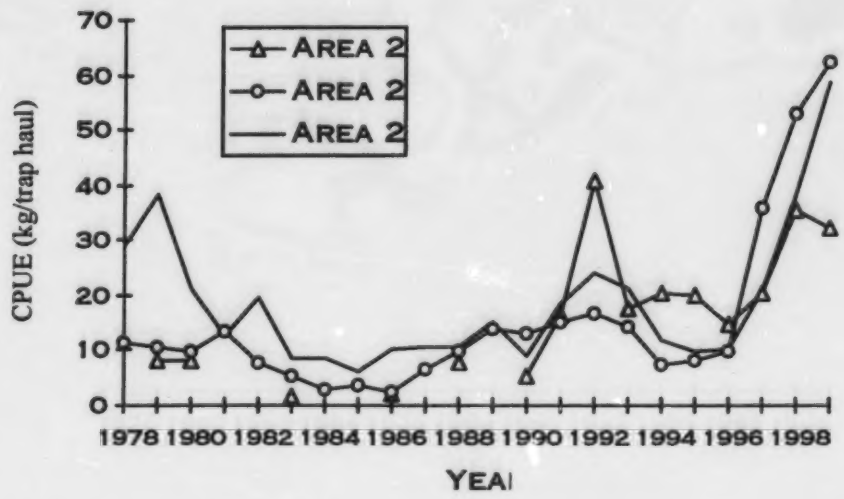

Figure 8. CPUE for Areas 20, 21 and 22 from 1978 to 1999.

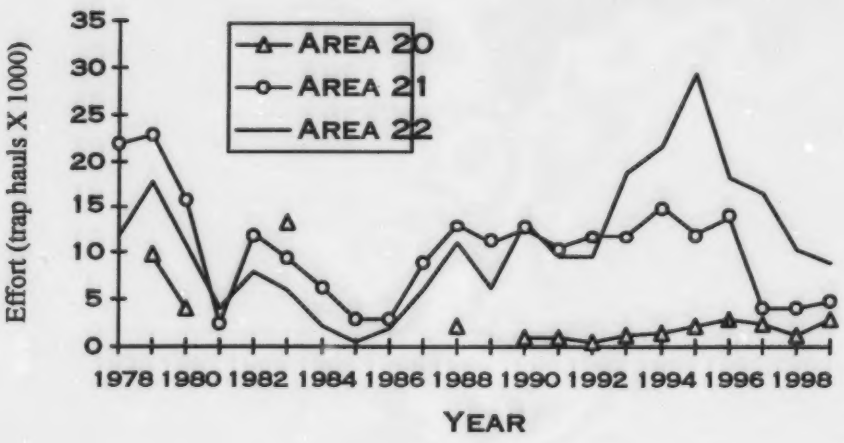

Figure 9. Fishing effort for Areas 20, 21 and 22 from 1978 to 1999.

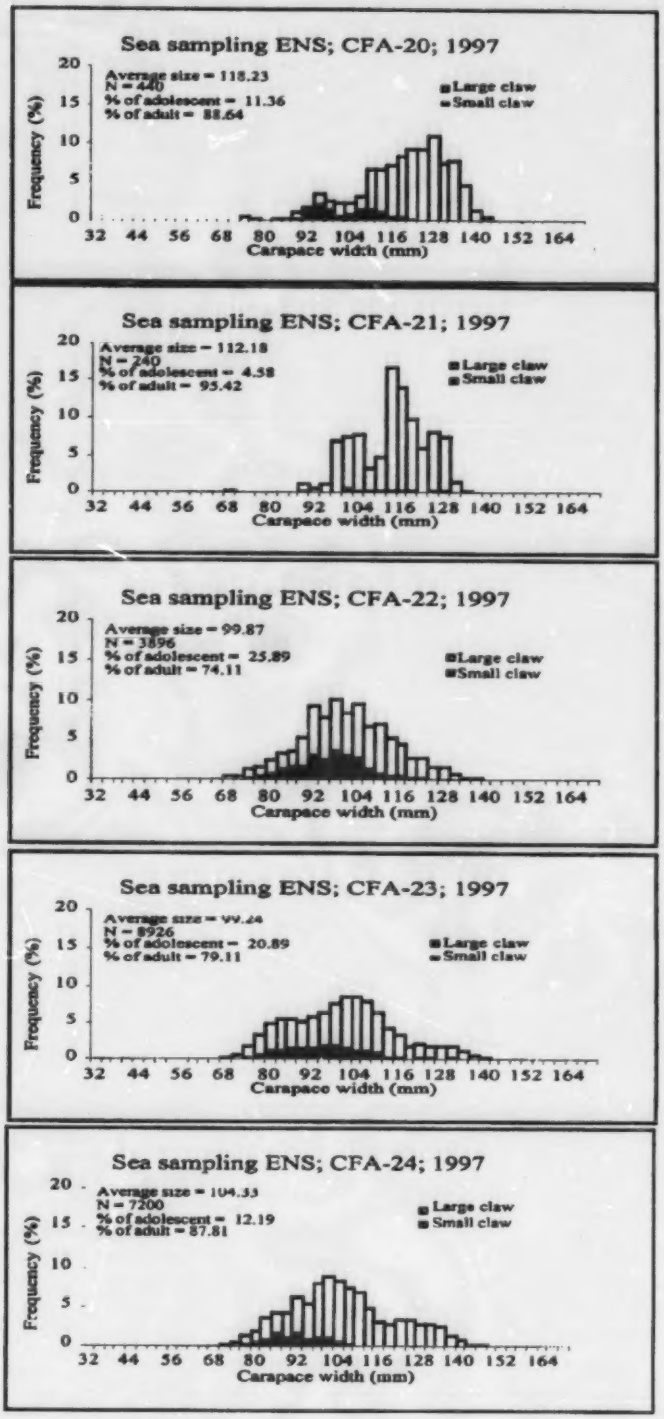

Figure 10. Size frequency distribution from the sea sampling in 1997.

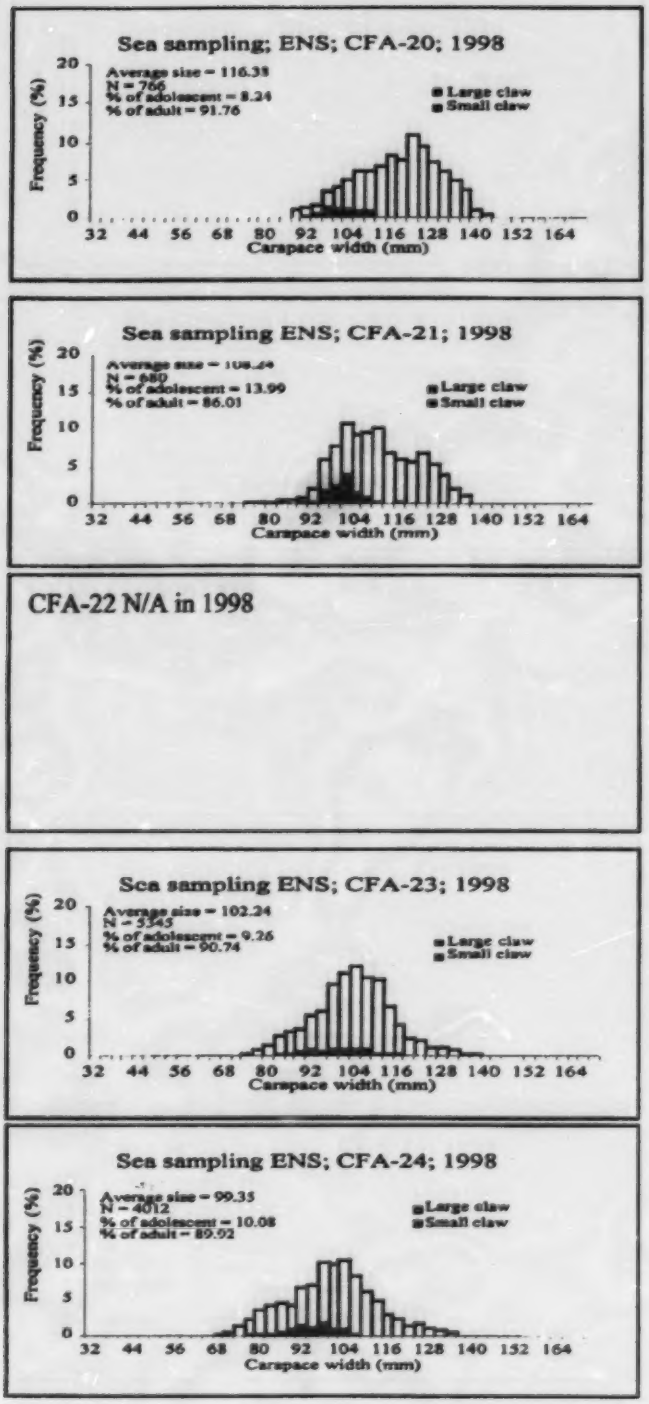

Figure 11. Size frequency distribution from the sea sampling in 1998.

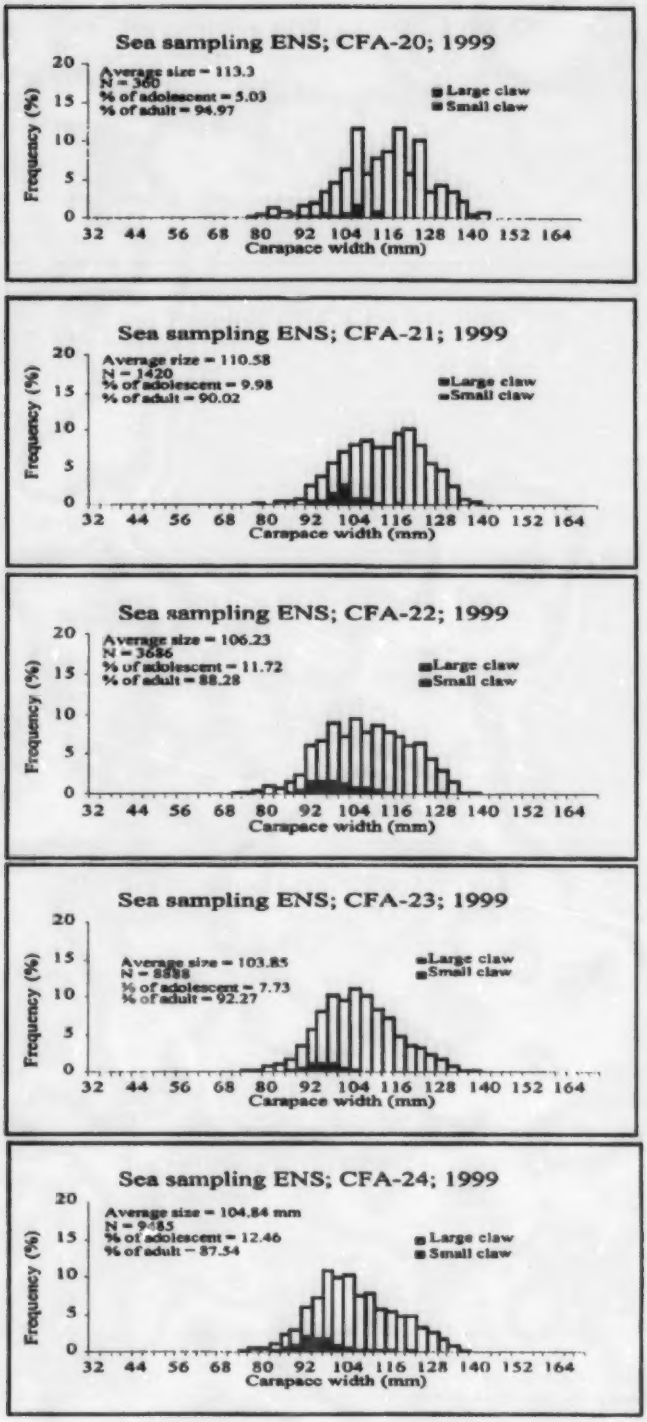

Figure 12. Size frequency distribution from the sea sampling in 1999.

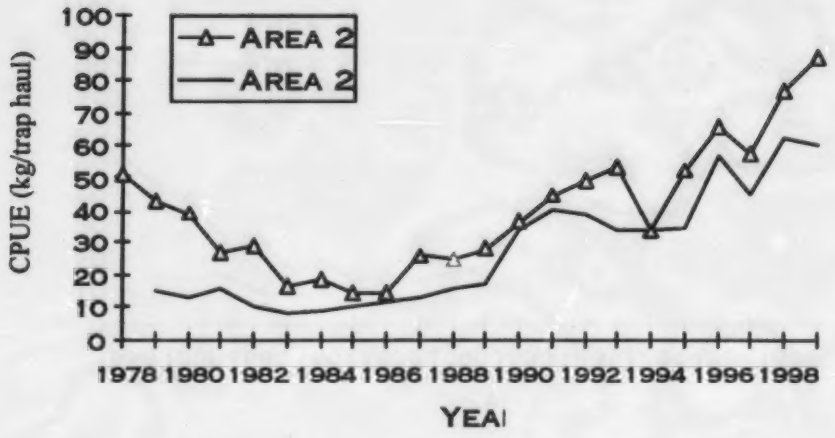

Figure 13. CPUE for Areas 23 and 24 from 1978 to 1999.

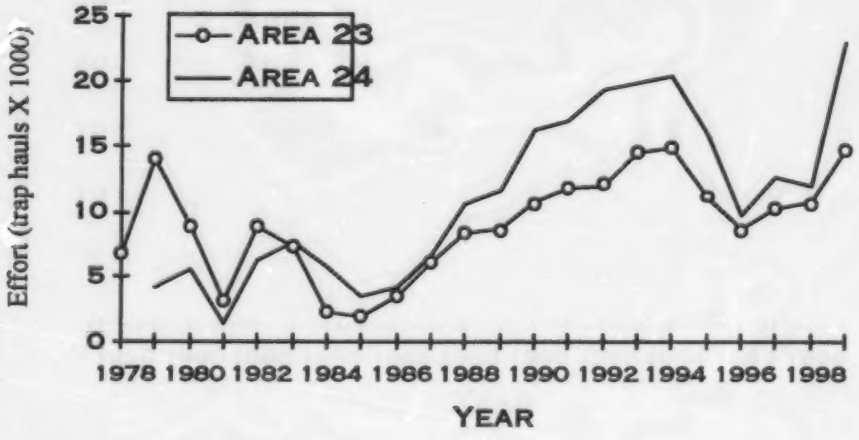

Figure 14. Fishing effort for Areas 23 and 24 from 1978 to 1999.

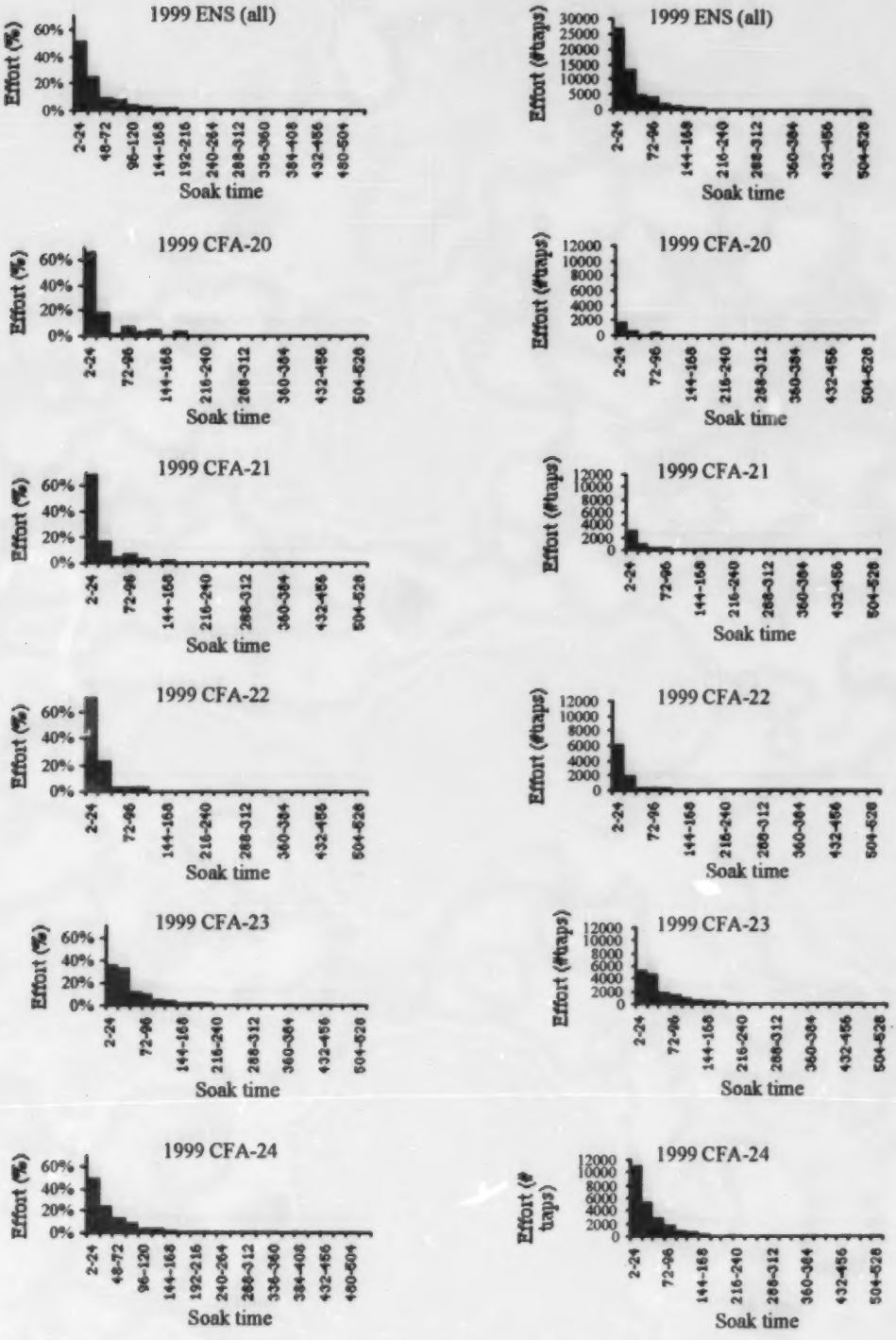

Figure 15. Distribution of fishing effort per 24 hour soak time in 1999.

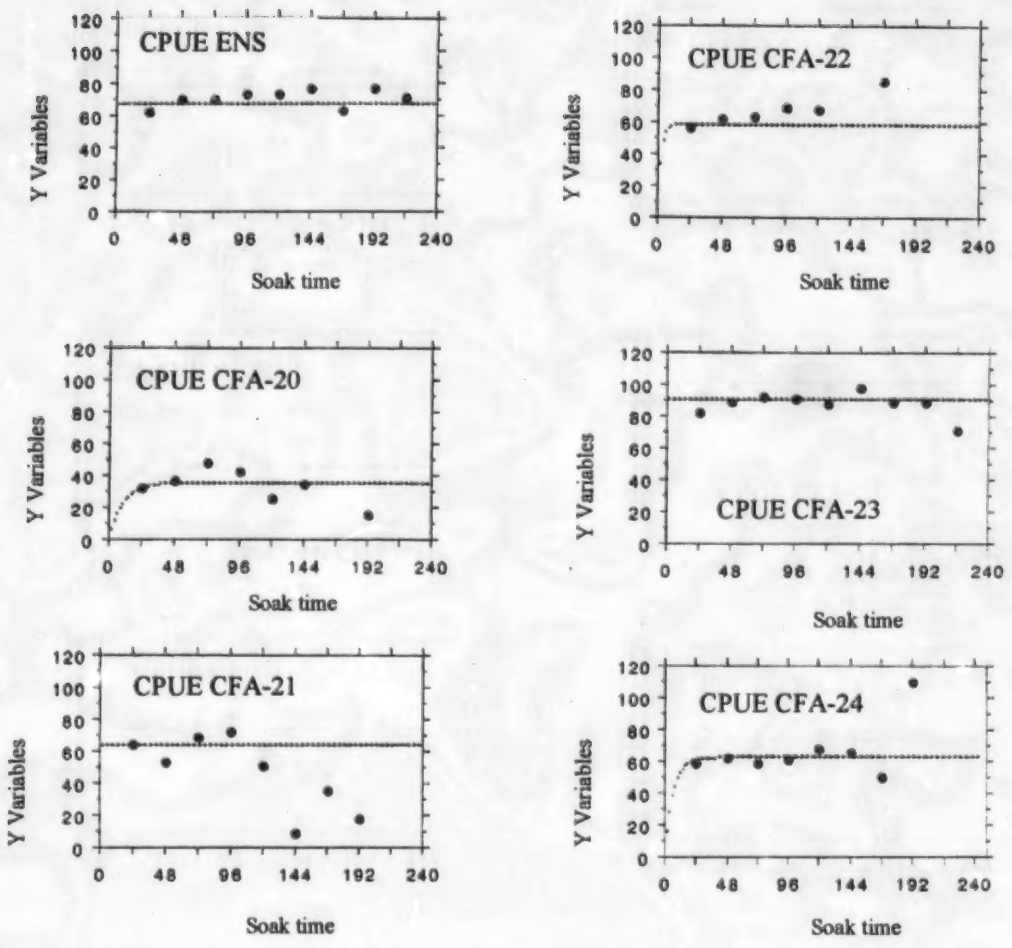

Figure 16. The power curves of CPUE in relation with soak time in ENS in 1999.

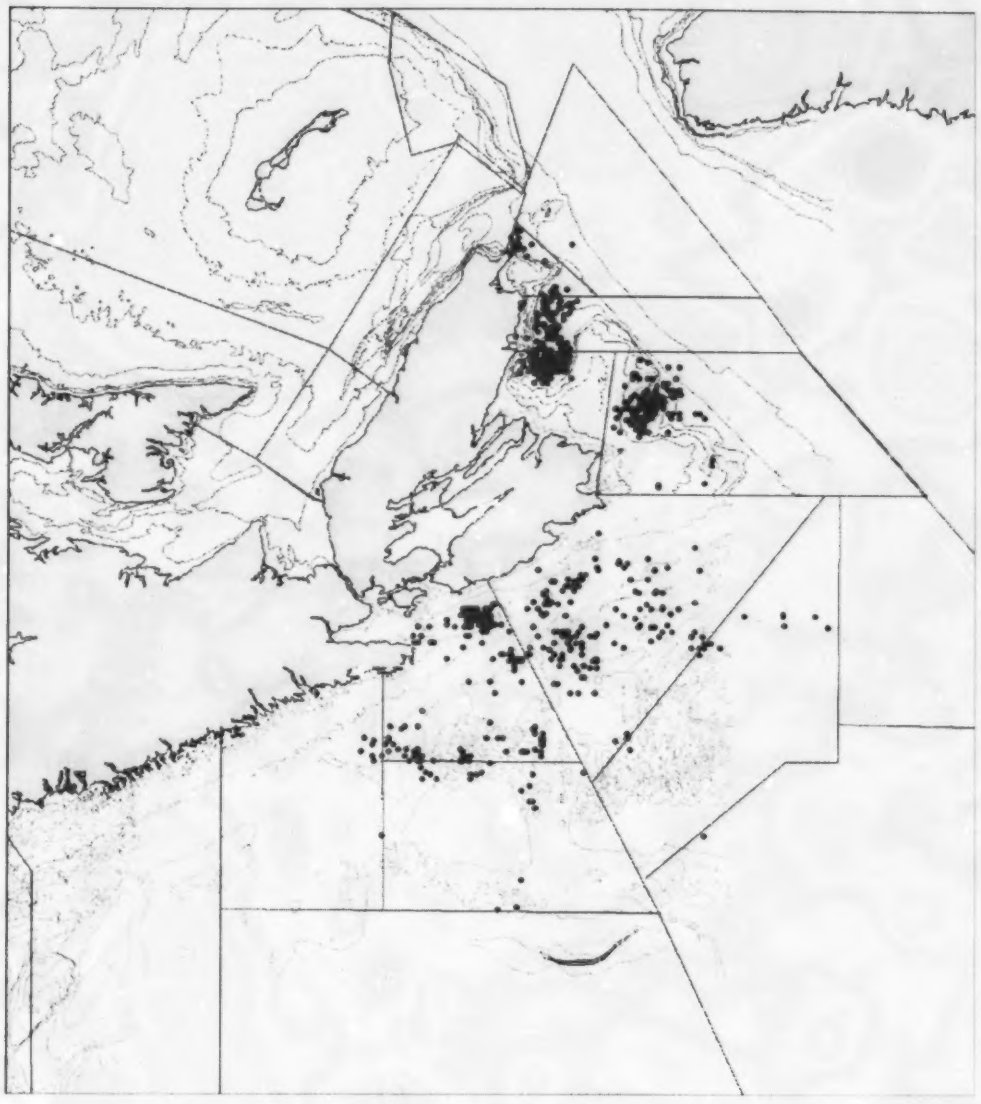

Figure 17. Reported logbook positions in eastern Nova Scotia in 1997.

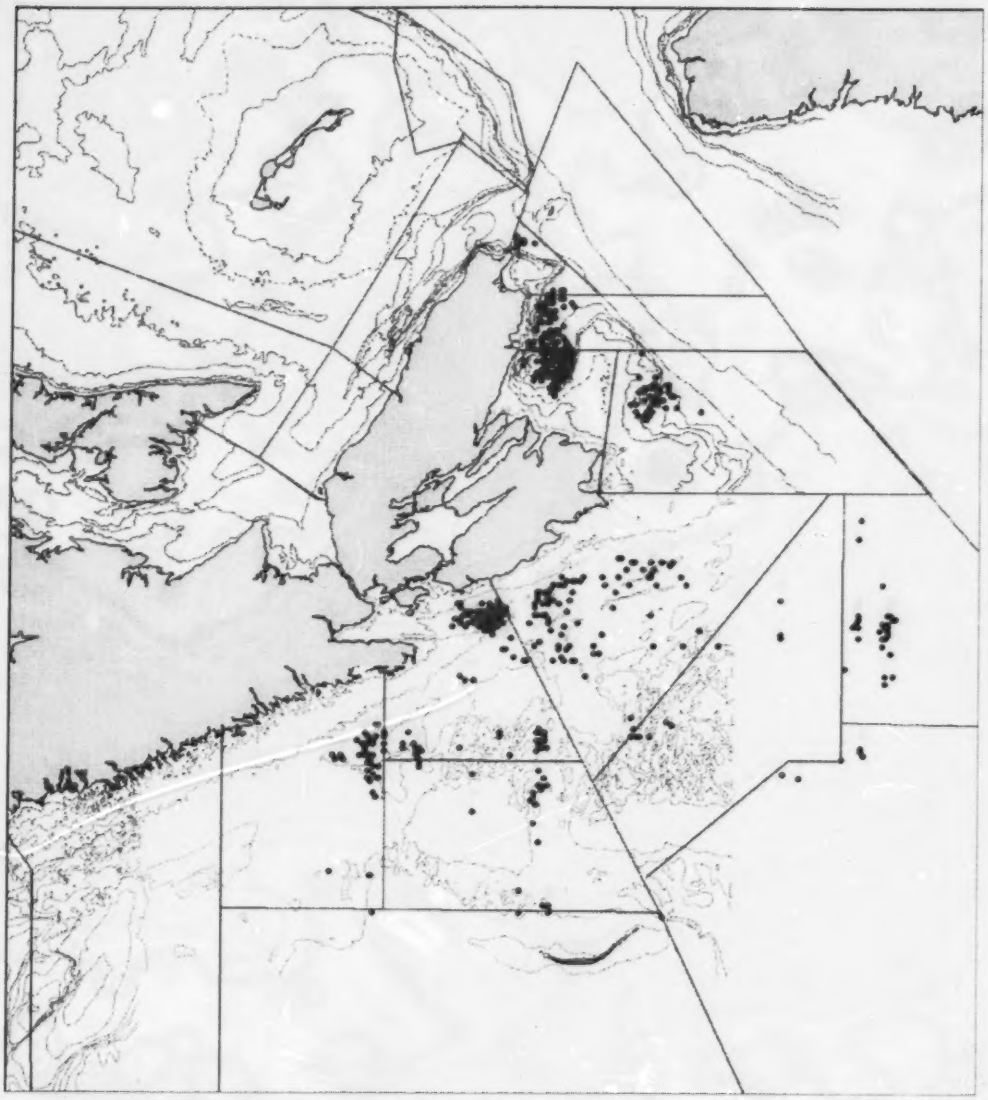

Figure 18. Reported logbook positions in eastern Nova Scotia in 1998.

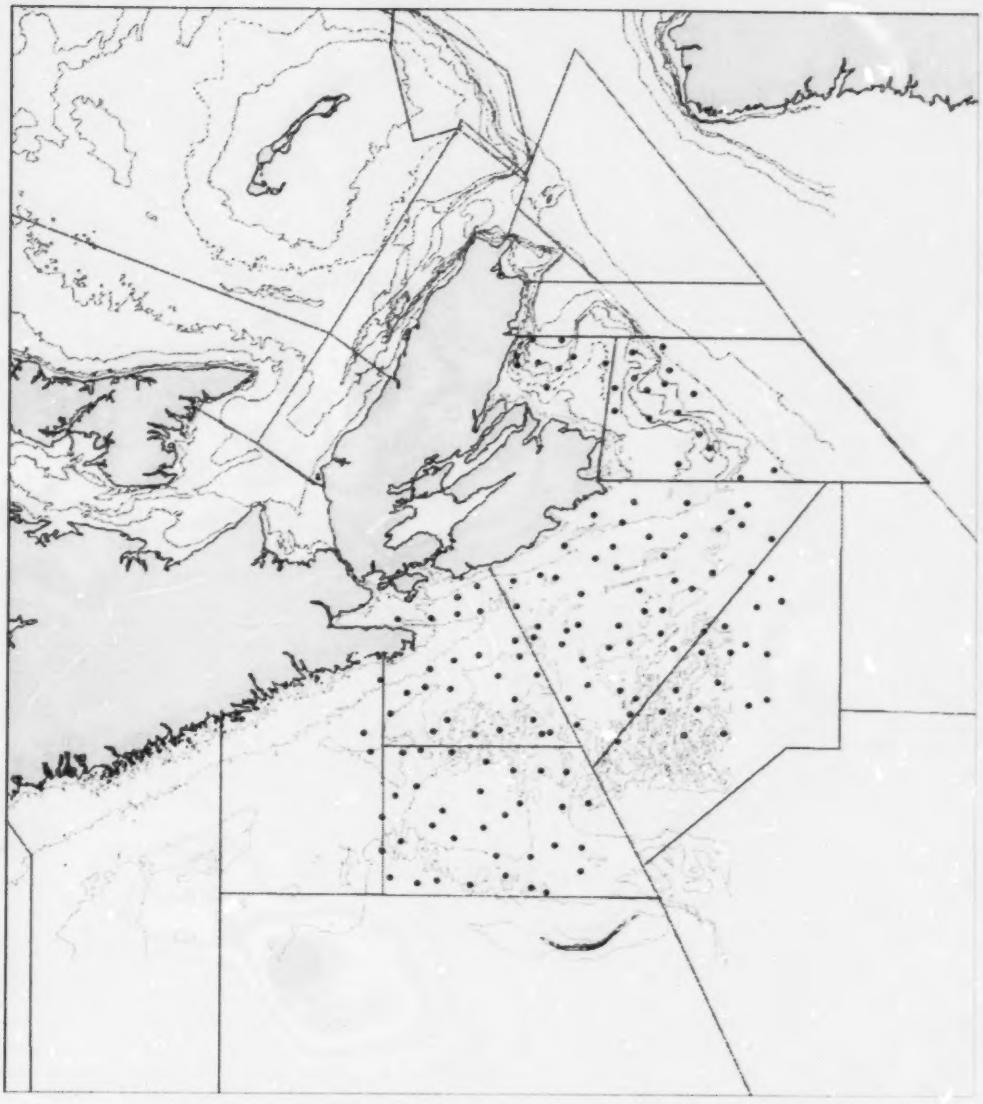

Figure 19. Location of the trawl survey stations (N=150) in 1997.

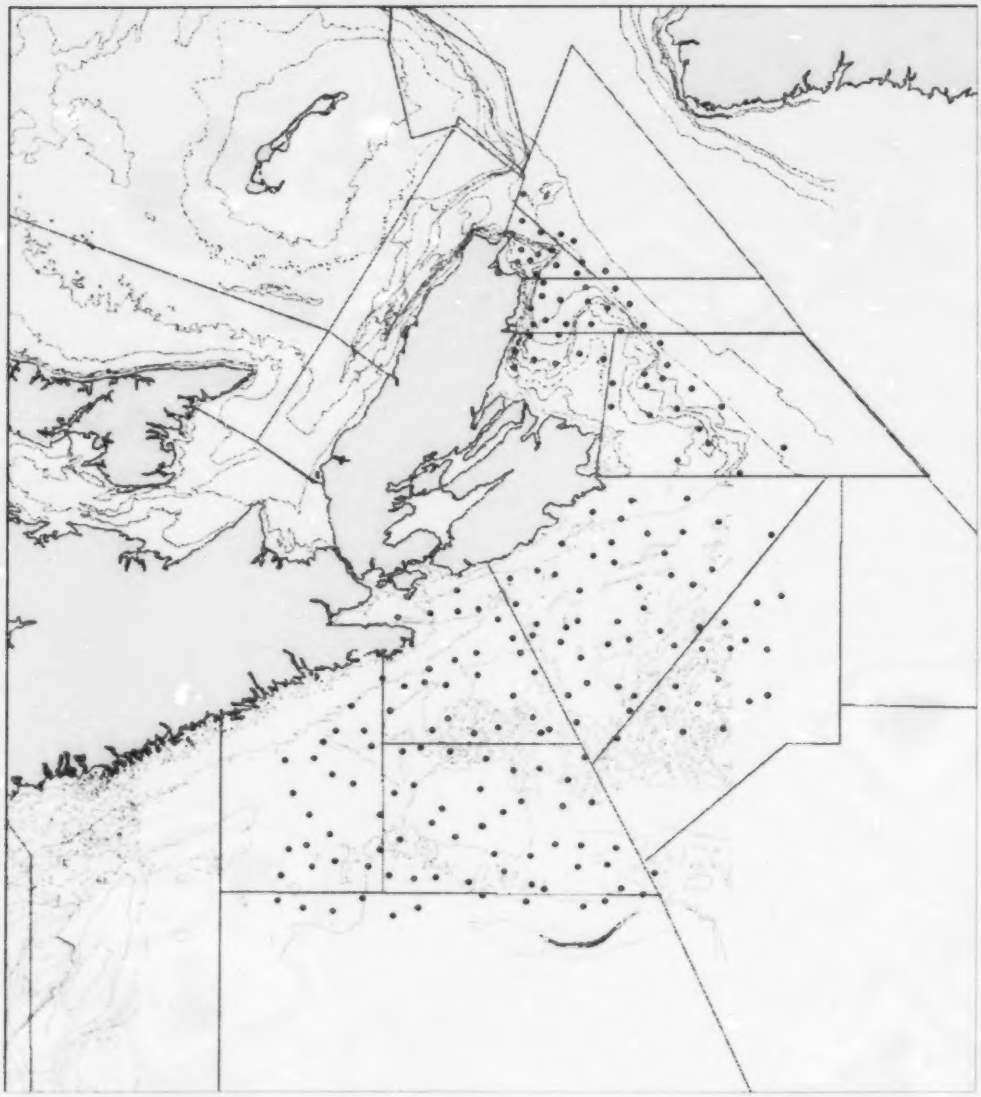

Figure 20. Location of the trawl survey stations (N=214) in 1998.

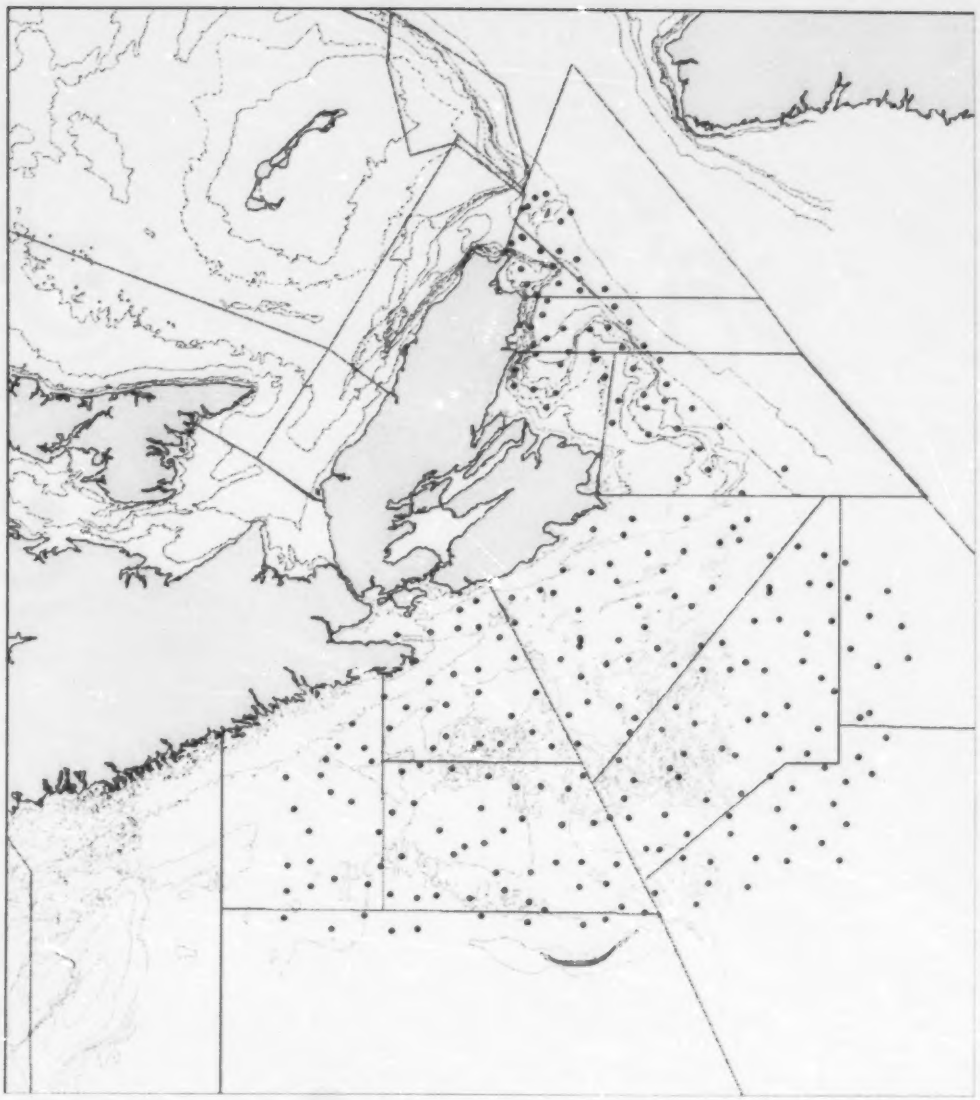

Figure 21. Location of the trawl survey stations (N=274) in 1999.

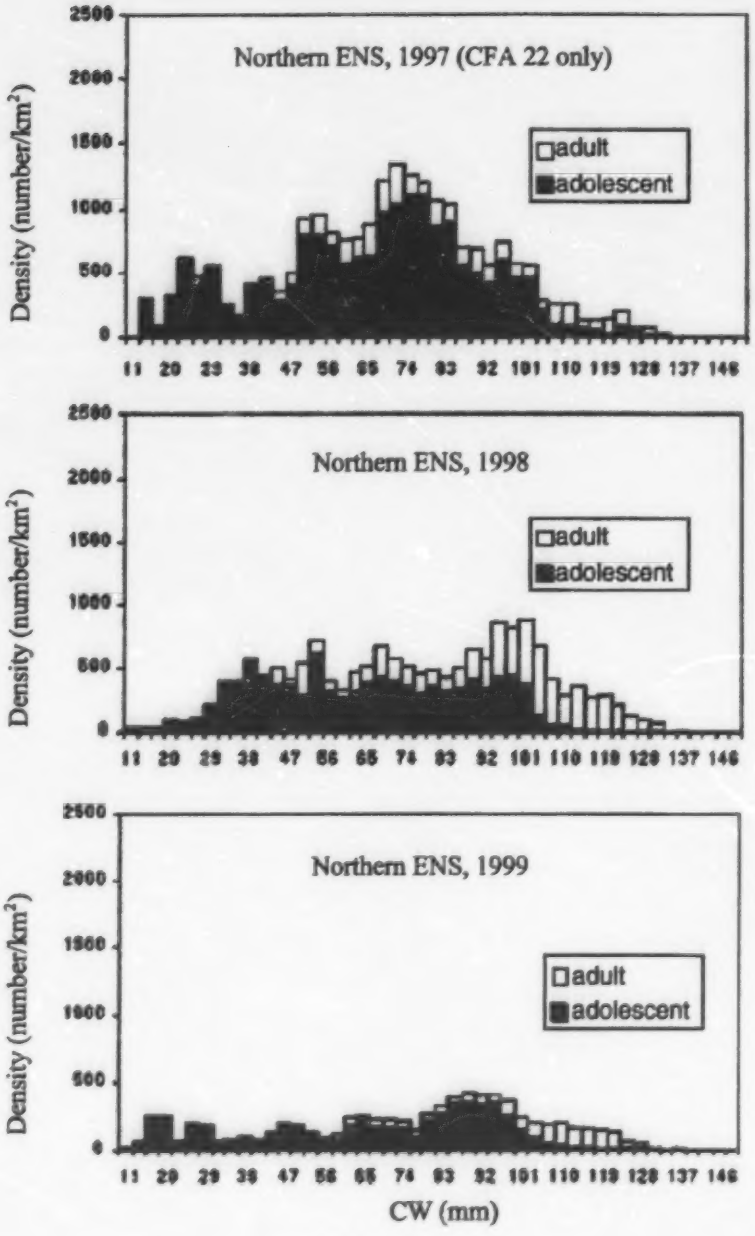

Figure 22. Survey size frequency of male crab in northern ENS from 1997 to 1999.

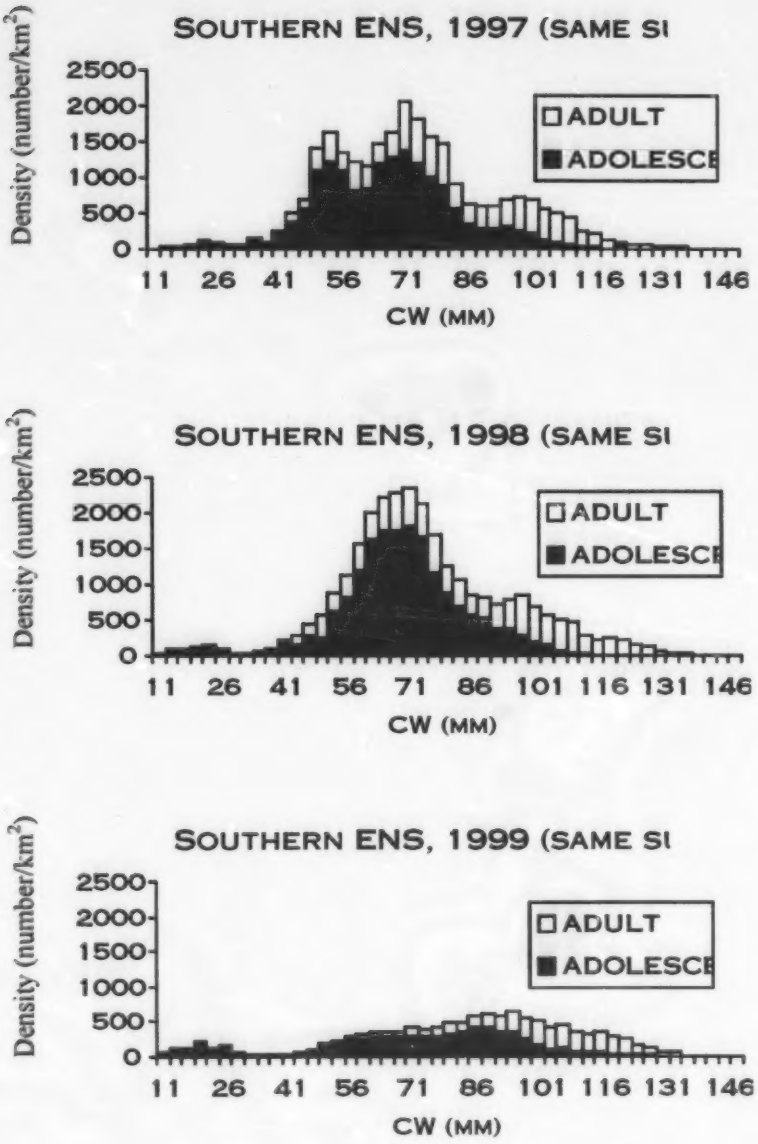

Figure 23. Survey size frequency of male crab in southern ENS from 1997 to 1999 for the same surface surveyed (original surveyed area).

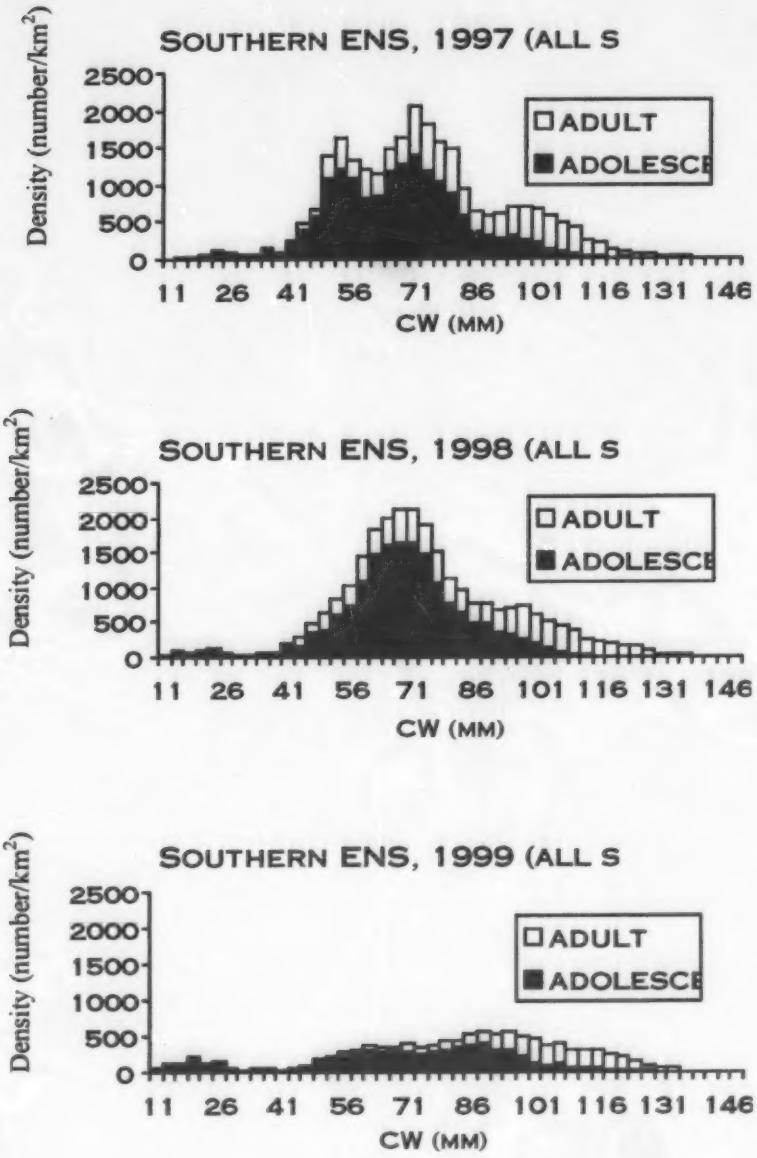

Figure 24. Survey size frequency of male crab in southern ENS from 1997 to 1999 for the total surface surveyed every year.

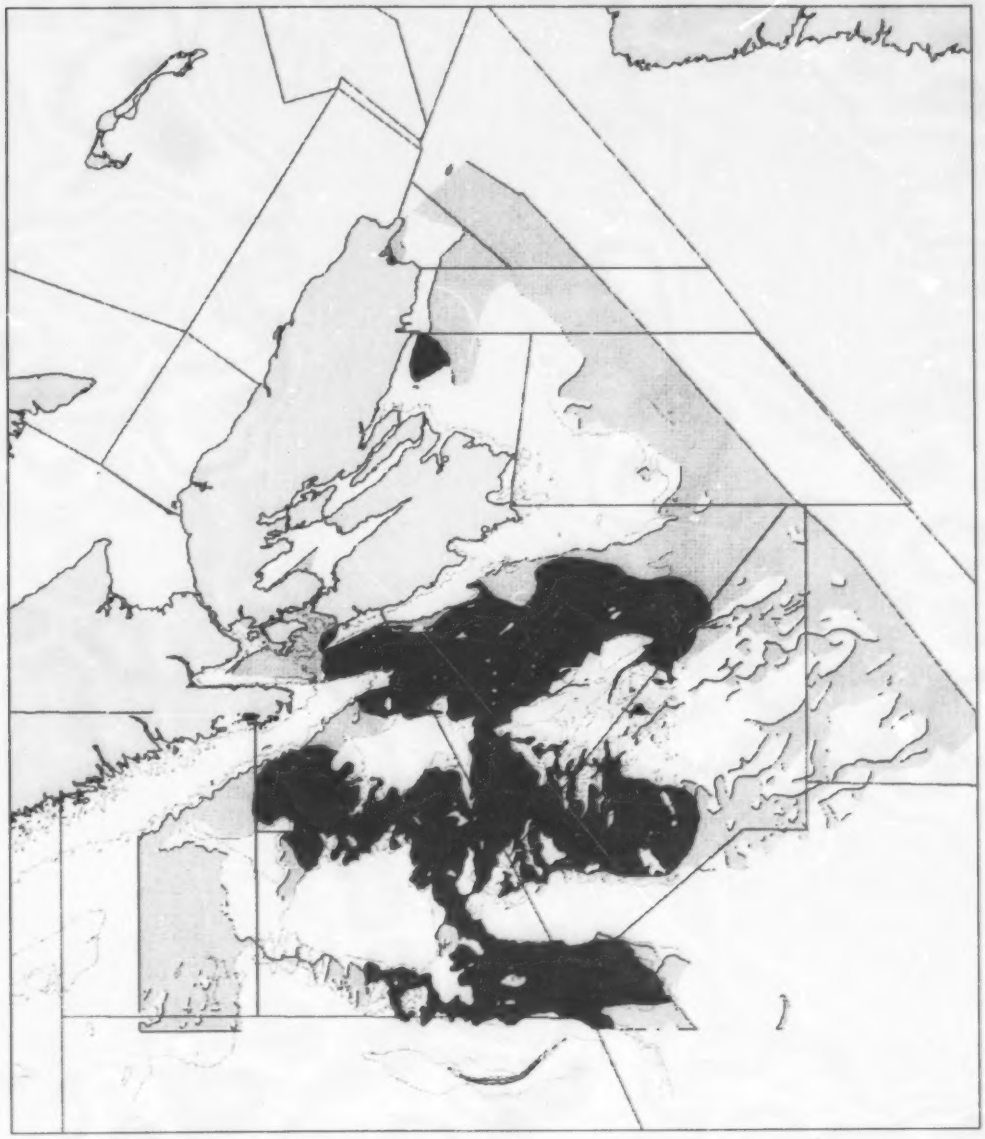

Figure 25. Snow crab density distribution found in eastern Nova Scotia in 1997.

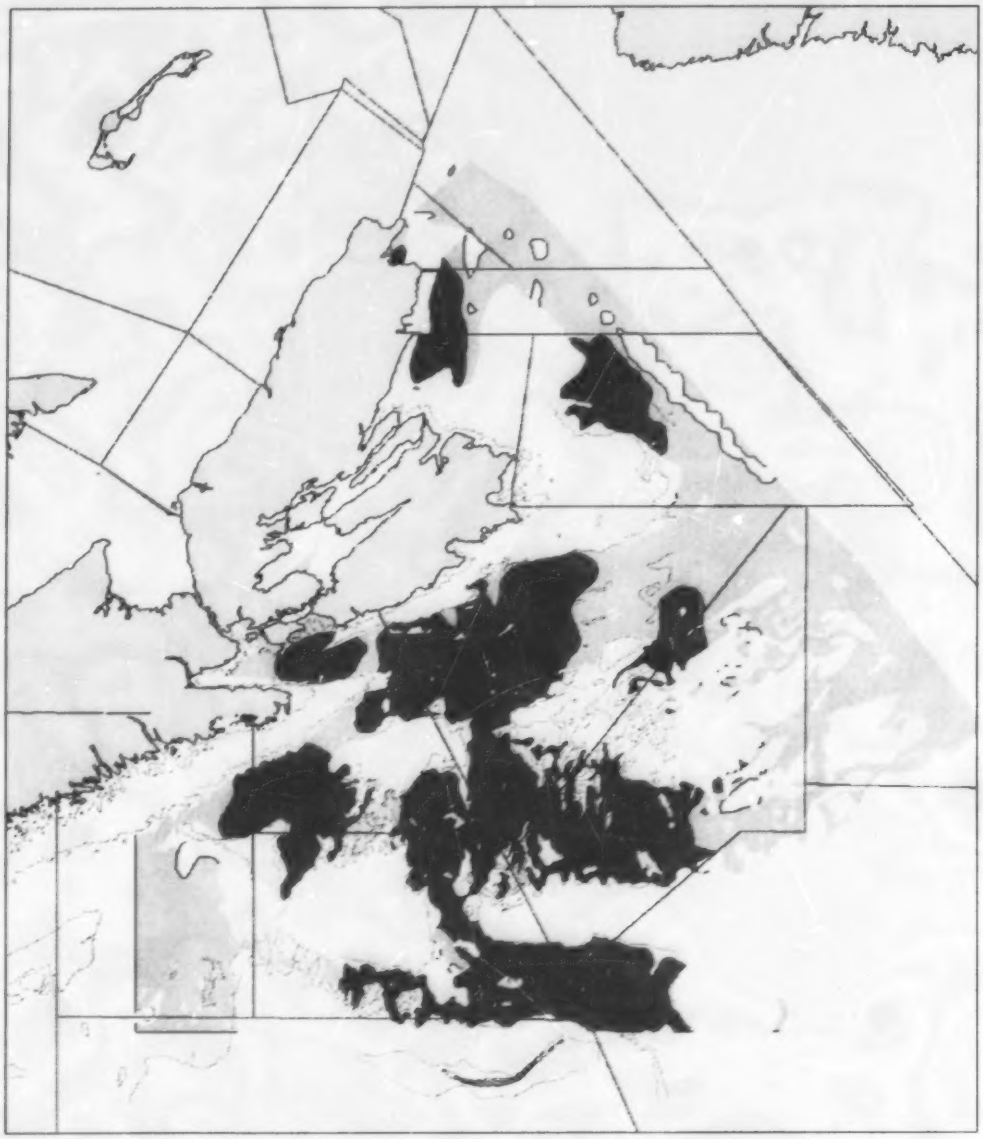

Figure 26. Snow crab density distribution found in eastern Nova Scotia in 1998.

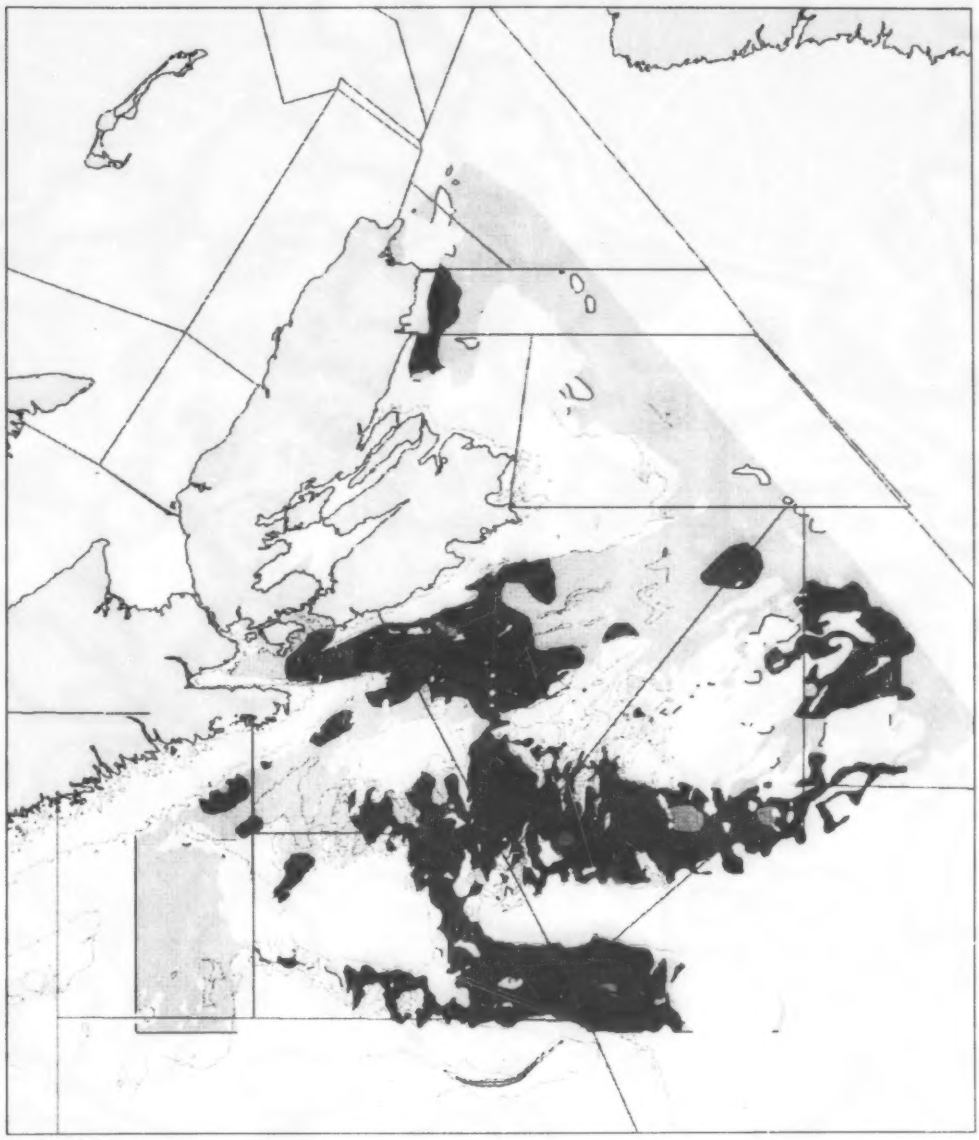

Figure 27. Snow crab density distribution found in eastern Nova Scotia in 1999.

Appendix 1

Classification of carapace stages developped for the SGSL stock based on carapace condition, durometer reading and corresponding approximate age after terminal molt (modified from CAFSAC 1991; Anonymous 1994).

Category	Stage	Durometer reading	Carapace condition	Approximate age after terminal molt
New soft	I	< 68	brightly colored, iridescent, soft, no epibionts, chelae easily bent.	0-5 months
Clean	II	variable	brightly colored, some iridescence, may have epibionts, chelae not easily bent	5 months- 1 year
Inter-mediate	III	> 68	dull brown dorsally and yellow-brown ventrally, no irridescence, shell abrasion evident, epibionts.	8 months -3 years
Old	IV	> 68	carapace very dirty but hard, decay may be present at leg joints, epibionts removable at processing plant.	2 - 5 years
Very old	V	variable	carapace very dirty and may be soft (durometer reading < 68), progression of decay may be evident, epibionts not removable at processing plant.	4-6 years